Single Aisle
TECHNICAL TRAINING MANUAL
T1+T2 (IAE V2500) (Lvl 2&3)
AUTO FLIGHT

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AUTO FLIGHT

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AUTOMATIC FLIGHT SYSTEM PRESENTATION (2)

GENERAL

The Automatic Flight System (AFS) gives pilots functions that reduce their workload and improve safety and regularity of the flight. The AFS is designed around:
- 2 Flight Management and Guidance Computers (FMGCs),
- 2 Flight Augmentation Computers (FACs),
- 2 Multipurpose Control and Display Units (MCDUs),
- 1 Flight Control Unit (FCU).

CONTROLS

The FCU and the MCDUs let the pilots control the functions of the FMGCs. The FAC engagement P/BSWs and the RUDder TRIM control panel are connected to the FACs. The MCDUs are used for long-term control of the aircraft and do the interface between the crew and the FMGC allowing the management of the flight. The FCU is used for short-term control of the aircraft and is the interface required for transmission of engine data from the FMGC to the Full Authority Digital Engine Control (FADEC).

FMGC

There are two interchangeable FMGCs. Each FMGC is made of two parts: the Flight Management (FM) part and the Flight Guidance (FG) part. The FM part gives the functions related to flight plan definition, revision and monitoring and the FG part gives the functions related to the aircraft control.

FAC

There are two interchangeable FACs. The basic functions of the FACs are the rudder control and the flight envelope protection.

NOTE: The FAC includes an interface between the AFS and the Centralized Fault Display System (CFDS) called Fault Isolation and Detection System (FIDS).

OTHER SYSTEMS

The AFS is connected to the majority of the aircraft systems.
Examples of AFS data exchanges:
- reception of the aircraft altitude and attitude from the Air Data/Inertial Reference System (ADIRS),
- transmission of autopilot orders to the ELevator and Aileron Computers (ELACs).

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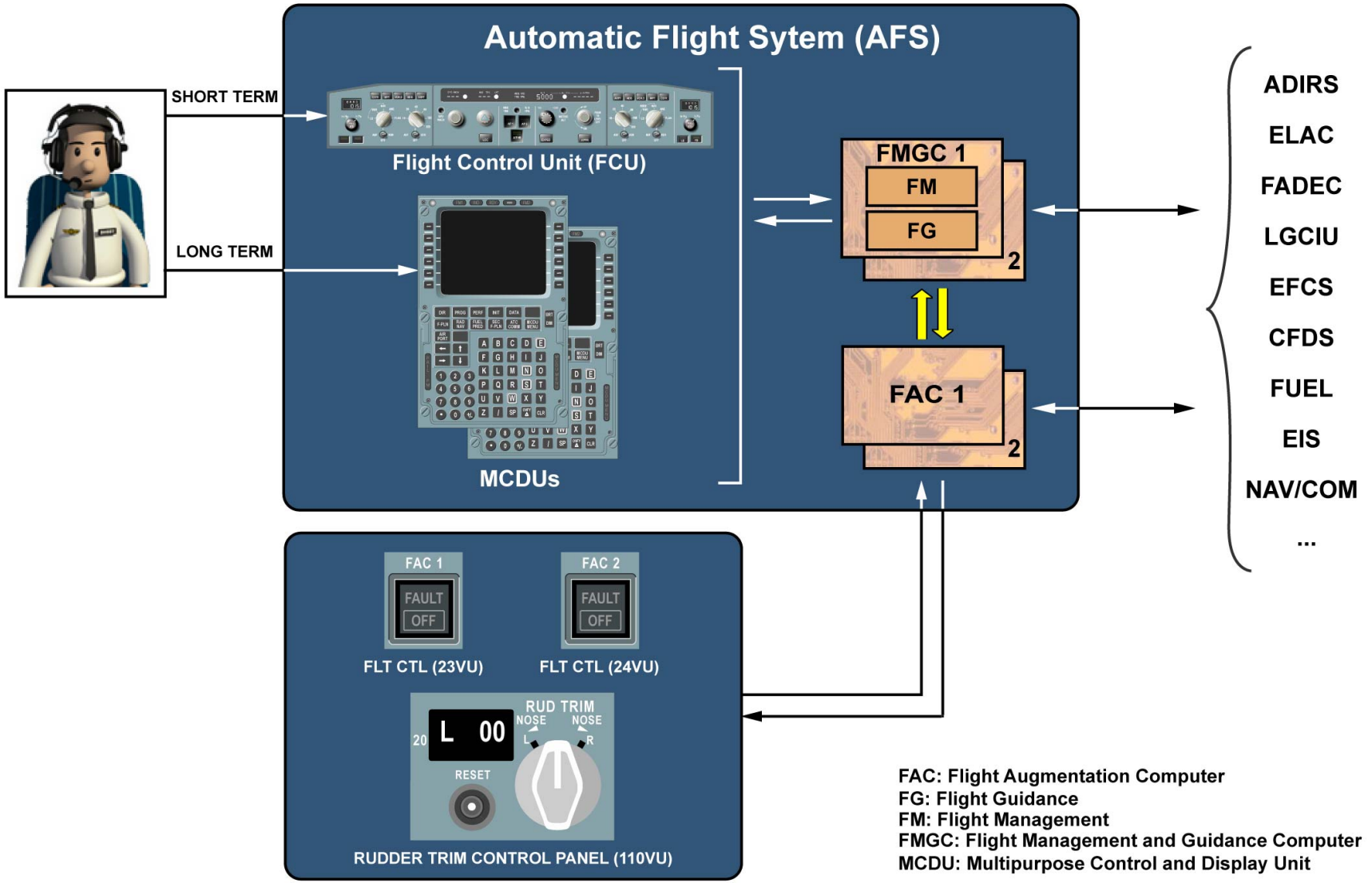

GENERAL ... OTHER SYSTEMS

AUTOMATIC FLIGHT SYSTEM PRESENTATION (2)

COMPONENT LOCATION

The AFS computers are located in the aft avionics rack (80VU).

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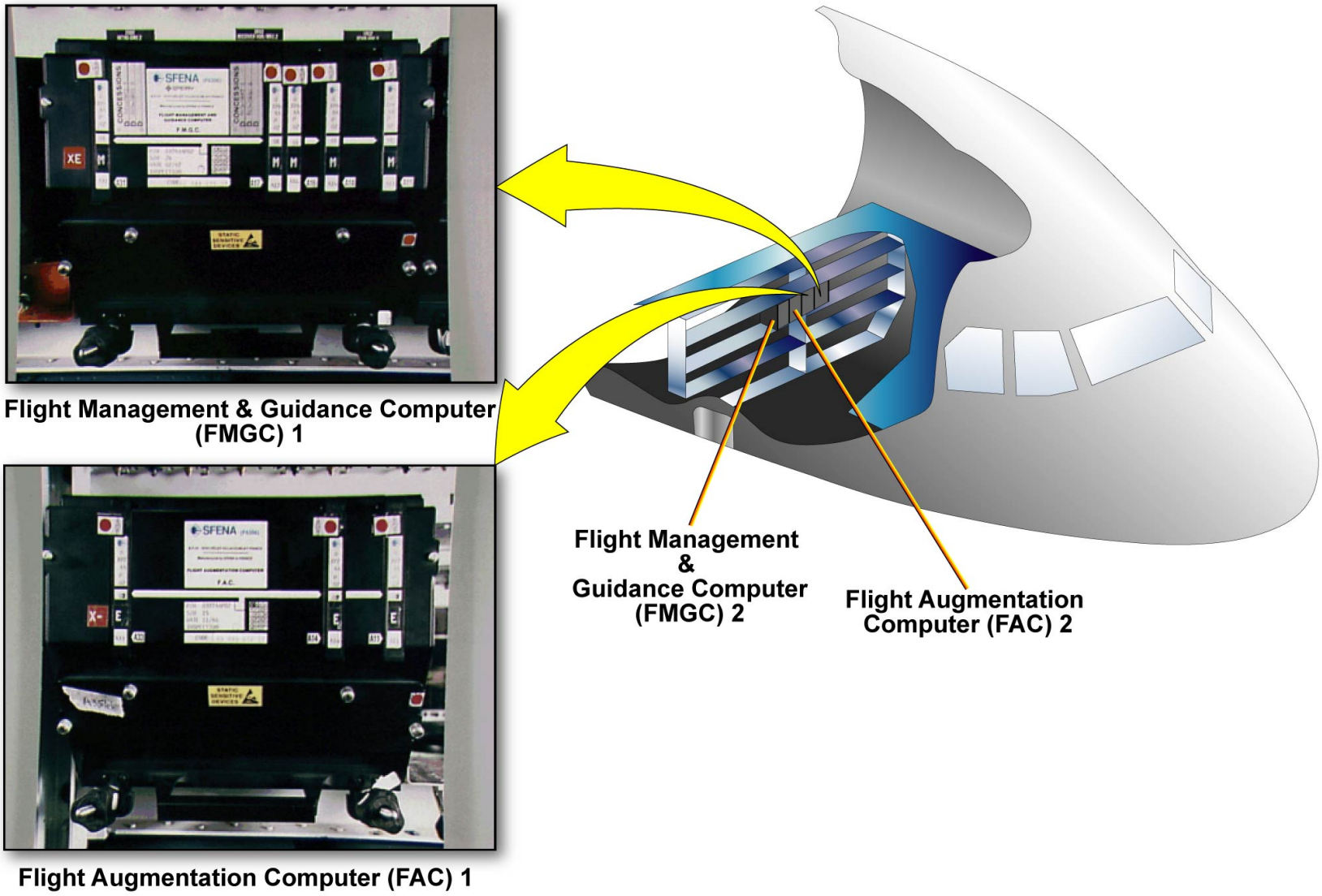
Flight Management & Guidance Computer (FMGC) 1
Flight Augmentation Computer (FAC) 1
Flight Management & Guidance Computer (FMGC) 2
Flight Augmentation Computer (FAC) 2

COMPONENT LOCATION

FAC GENERAL (2)

FUNCTIONS

The basic functions of the Flight Augmentation Computer (FAC) are:
- yaw damper,
- rudder trim,
- rudder travel limitation,
- flight envelope protection,
- Fault Isolation and Detection System (FIDS).

YAW DAMPER

The yaw damper has four functions and controls the rudder via yaw damper actuators. Upon Flight Management and Guidance Computer (FMGC), ELevator Aileron Computer (ELAC) or FAC orders, the yaw damper provides:
- dutch roll damping,
- turn coordination in cruise,
- engine failure compensation in auto flight,
- yaw guidance order execution.

RUDDER TRIM

The rudder trim orders come from the RUDder TRIM selector, or from the FMGC to control the rudder via the rudder trim actuator.
The rudder trim gives:
- the manual trim with RUD TRIM selector,
- auto trim on yaw axis and the generation of engine failure recovery function when the autopilot is engaged.

RUDDER TRAVEL LIMITATION

The rudder travel limiting unit limits the deflection of the rudder according to the aircraft speed.
The rudder travel limiting function:
- limits the deflection for structure integrity,
- prevents excessive deflections which would penalize the aircraft performance.

Aircraft speed information is given by the Air Data/Inertial Reference Units (ADIRUs).

FLIGHT ENVELOPE PROTECTION

For flight envelope protection, the FAC computes the various characteristic speeds for aircraft operation, the low energy warning, the excessive Angle-Of-Attack (AOA) and wind shear detections. The characteristic speeds are computed using data from the ADIRU, the Landing Gear Control Interface Unit (LGCIU), the FMGC, and the Slat Flap Control Computer (SFCC). Then, they are displayed on the PFDs. The alpha floor (excessive AOA) and wind shear detections are sent to the FMGCs. The low energy warning computation is sent to the Flight Warning Computers (FWCs) which generate an aural warning: "SPEED, SPEED, SPEED".

FIDS

For maintenance purposes, the FIDS centralizes the failure information from the various BITE of the AFS computers and provides an interface between these BITEs and the Centralized Fault Display Interface Unit (CFDIU). The FIDS function is only active in FAC 1.

CONTROLS

Each FAC receives inputs from its related P/BSW, the RUD TRIM selector and the RUD TRIM RESET P/B. The RUD TRIM selector deflects the rudder. The RESET P/B returns the rudder to the neutral position.

DISPLAYS

Some of the data computed by the FAC is displayed:
- the characteristic speeds are displayed on the speed scale of the PFDs.

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- the rudder trim position is displayed on the F/CTL ECAM page and on the RUD TRIM control panel. The red WINDSHEAR indication is displayed in the center of both PFDs.

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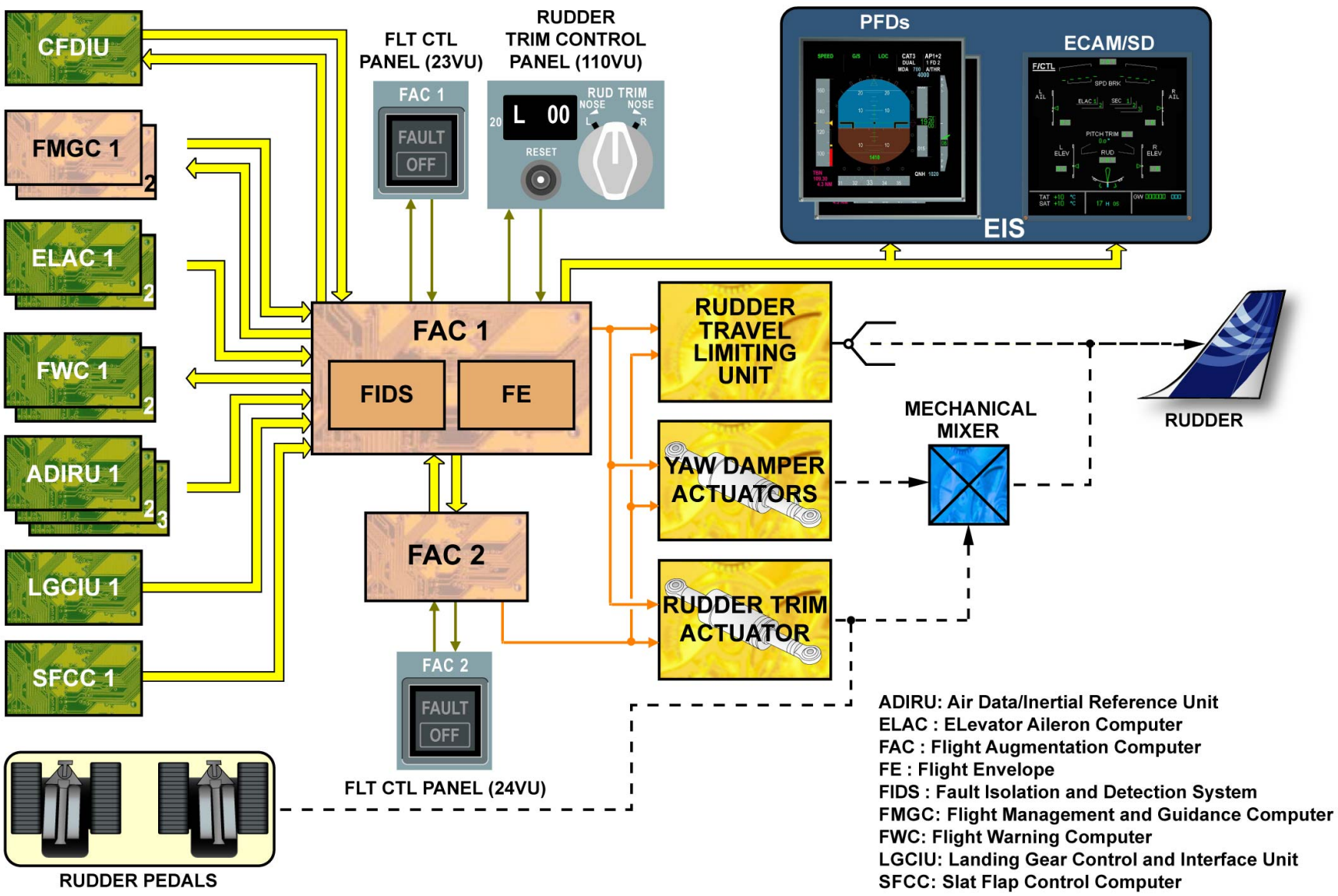

FUNCTIONS ... DISPLAYS

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FAC GENERAL (2)

COMPONENT LOCATION

The FAC computers, FAC (1, 2), are located in the aft avionics rack (80VU).

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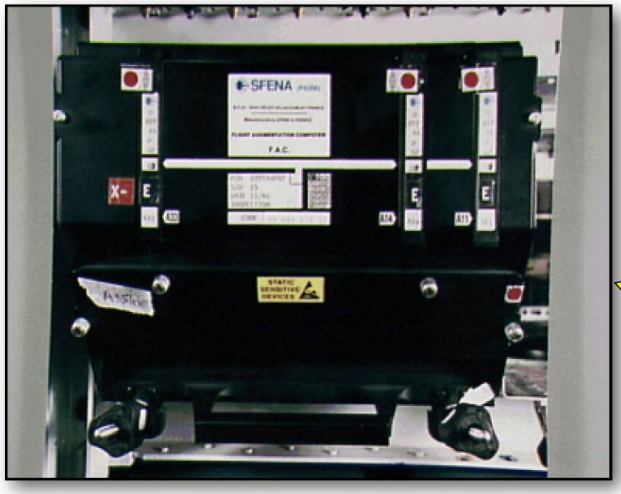
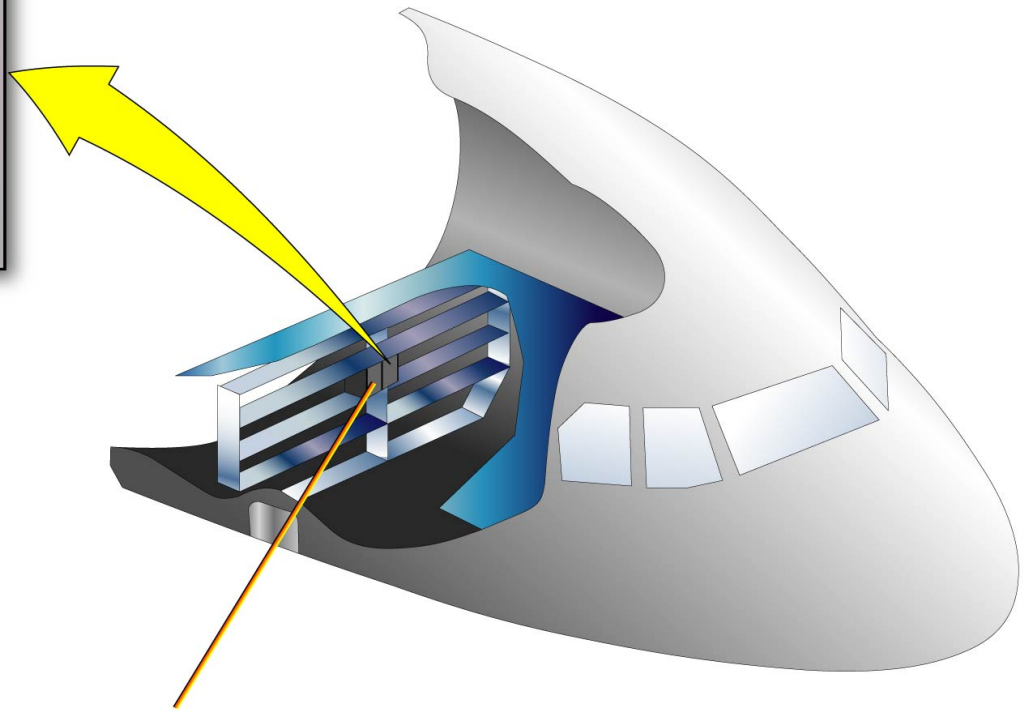


Flight Augmentation Computer (FAC) 1



Flight Augmentation Computer (FAC) 2

COMPONENT LOCATION

FMGC GENERAL (2)

CONTROLS

GENERAL

The Flight Management and Guidance Computer (FMGC) functions, Flight Management (FM) and Flight Guidance (FG), are mainly controlled from the Multipurpose Control and Display Units (MCDUs) and the Flight Control Unit (FCU).
Typical actions are:
- before departure, on the MCDUs, the pilots select the flight plan which will be followed later on by the aircraft.
- in flight, on the FCU, the pilots can engage the AP and can modify different flight parameters leading to an immediate change in the control of the aircraft.

MCDU

Basically, the MCDUs give the long-term interface between the crew and the FMGCs.
The MCDUs show, for example:
- the introduction or the definition, the modification and the display of flight plans,
- the display, the selection and the modification of the parameters associated with the FM functions,
- the selection of specific functions.

FCU

Basically, the FCU gives the short-term interface between the crew and the FMGCs.
For example, the FCU can be used for:
- the engagement of the AP, Flight Director (FD) and A/THR functions,
- the selection of required guidance modes (e.g. heading hold),
- the selection of various flight parameters (e.g. heading value).

MANAGEMENT

GENERAL

The FM part mainly gives the flight plan selection with its lateral and vertical functions. The FM part gives the navigation, performance optimization, radio navigation tuning and information display management. Data computed by the FM part is occasionally used by the FG part.

FLIGHT PLAN

A flight plan contains the various elements and constraints of the route the aircraft must fly along from take-off to landing. A flight plan can be selected, built-up, modified and monitored through the MCDU.

LATERAL FUNCTIONS

The main lateral functions are:
- aircraft position determination,
- Inertial Reference System (IRS) alignment through the MCDU,
- automatic or manual (through MCDU) selection of VOR, DME, ILS, ADF frequencies,
- guidance computation along the lateral flight plan.

A navigation database supplies all necessary information to build a flight plan; however pilots can enter other data using the MCDU.

VERTICAL FUNCTIONS

The main vertical functions are:
- optimized speed computation; the resulting target speed being used as reference for guidance functions,
- performance predictions as time, fuel, altitude, wind at various points of the flight,
- guidance computation along the vertical flight plan.

A performance database supplies necessary data; however pilots have to enter other data using the MCDU.

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GUIDANCE

GENERAL

The FG part gives the AP, FD and A/THR functions. These functions work according to modes generally chosen on the FCU. The normal way to operate the aircraft is to use the management part as reference source for the guidance part.

AP

The AP function calculates the signals for the flight controls in order to follow the selected modes. The AP controls the pitch, roll and yaw axis according to the selected modes. Example of AP mode: Altitude hold.

FD

The FD displays the guidance commands on both PFDs, allowing the pilots to fly the aircraft manually according to the FMGC demands.
Two cases have to be considered:
AP not engaged:
- the FD function displays symbols on the PFD which gives orders to the pilot to maintain the desired parameter(s). In this case, the pilot follows these orders by acting on the flight controls.

AP engaged:
- the FD function displays symbols on the PFDs representing the AP orders to be monitored by the pilot.

A/THR

The A/THR function calculates the signal necessary for engine control in order to follow a given mode.
Example of A/THR mode: Acquisition and holding of a speed or a Mach number.

DISPLAYS

GENERAL

Various displays are used to present Flight Management and Guidance System (FMGS) data and information. The main displays presenting flight management and guidance information are:
- the MCDUs (display part),
- the FCU (display Part),
- the PFDs,
- the NDs,
- the ECAM/EWD and ECAM STATUS pages.

MCDU

The MCDUs display all data related to the management part. Example: Identification of the successive waypoints of the flight plan.

FCU

The FCU is also considered as a display as it includes indication lights and Liquid Crystal Display (LCD) windows.
The FCU includes:
- lights giving mode indications,
- LCD windows showing reference parameters.

Example: During a climb with AP, the altitude window displays the altitude the aircraft is going to capture.

PFD

The PFDs mainly display the FD symbols and the status of guidance functions and their modes. They also display reference parameters.
Example: The target speed value is represented by a symbol on the speed scale of the PFD.

ND

The NDs mainly display the flight plan and various navigation data.
Example: Airports or waypoints around the present position of the aircraft.

ECAM

The ECAM/EWD page presents warning messages related to the function or computer failures. The ECAM STATUS page displays the landing capabilities.

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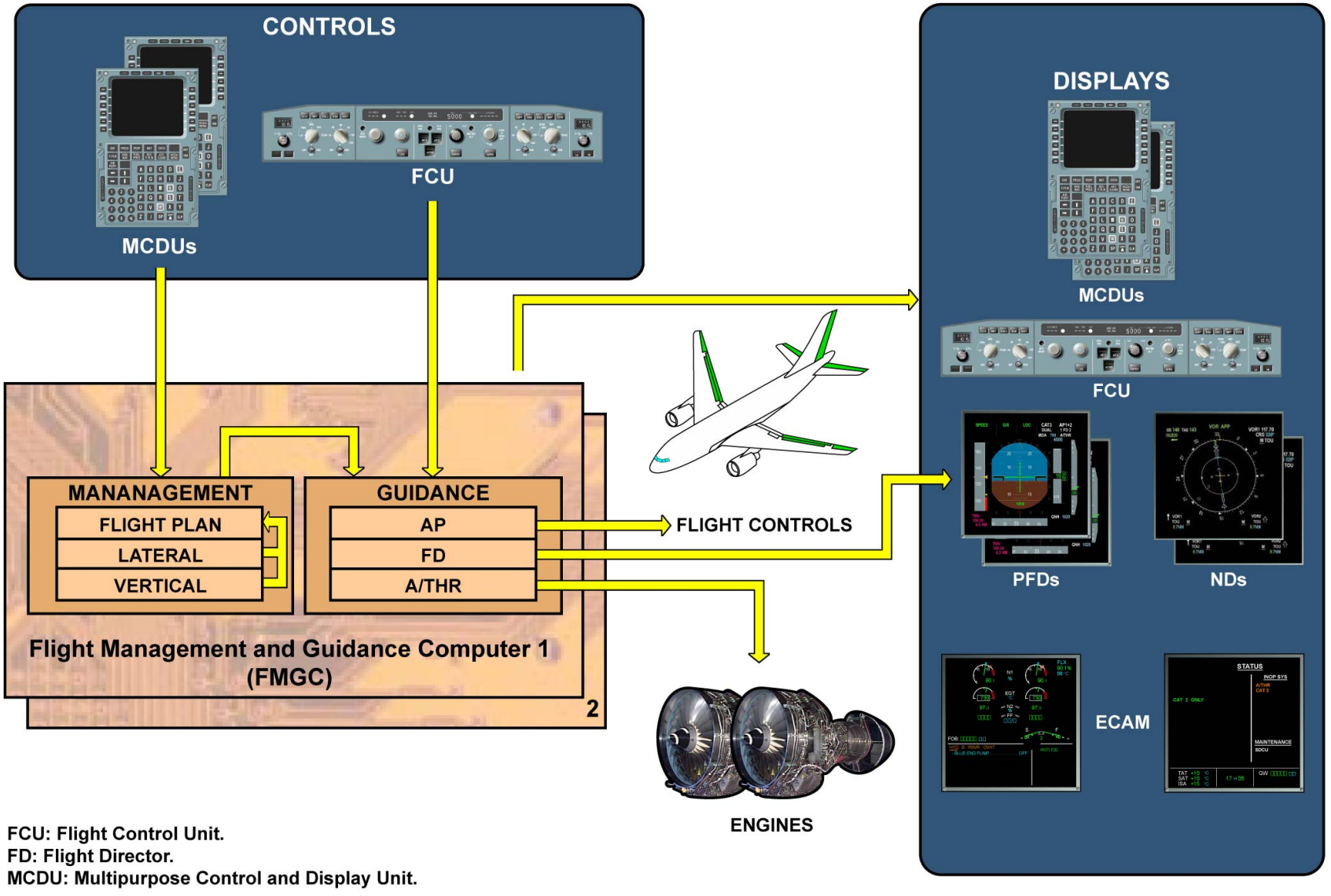

CONTROLS ... DISPLAYS

AUTOPILOT PRESENTATION (2)

GENERAL

The AP is engaged from the Flight Control Unit (FCU) by the related pushbuttons. AP engagement is indicated by the illumination of the AP 1 P/BSW or/and the AP 2 P/BSW (Three green bars) and by the white "AP1", "AP2" or "AP1+ 2" indication on the top right corner of each PFD. The AP guidance modes are selected from the FCU or the Flight Management and Guidance Computers (FMGCs). The AP function is a loop where, after a comparison between real and reference parameters, the FMGC computes orders, which are sent to the flight controls. The loop is closed by real values coming from sensors and given by other systems (e.g. ADIRS) to the FMGCs. When the AP is engaged, the load thresholds on the rudder pedals and the side sticks are increased. If a pedal or side stick load threshold is overridden, the AP disengages.

MODES

There are lateral modes and vertical modes. Basically, one of each is chosen by the pilot or by the system. The AP being engaged, one lateral mode and one vertical mode are simultaneously active.
According to flight phases, the lateral mode controls:
- the ailerons via the ELevator Aileron Computers (ELACs),
- the spoilers via the ELACs and the Spoiler Elevator Computers (SECs),
- the rudder via the Flight Augmentation Computers (FACs),
- the nose wheel via the ELACs and the Braking/Steering Control Unit (BSCU).

The vertical mode controls the elevators and the THS via the ELACs.

GROUND

For maintenance purposes, the AP can be engaged on ground with both engines shut down. Hydraulic power is not required.
When an engine is started, the AP disengages.

TAKE-OFF

The AP can be engaged in flight, provided the aircraft has been airborne for at least 5 seconds.

CRUISE

In cruise, only one AP can be engaged at a time, priority given to the last engaged. Engaging the second AP disengages the first one. The ailerons and the spoilers execute the orders of lateral modes; the elevators and the THS execute the orders of vertical modes.

NOTE: The rudder is controlled not by the AP but directly by the FACs.

LANDING

If the airfield is equipped with ILS installations, the AP can perform a complete landing with approach, flare and roll out. A second AP can be engaged (AP 1 active, AP 2 in standby).

NOTE: The rudder is controlled by the AP via the FACs.
During roll out, the AP gives steering orders to the rudder and the nose wheel. These orders depend on the aircraft speed. Aileron and spoiler AP orders are null. The THS is reset to 0.5 nose up.

NOTE: The spoilers are directly controlled by the SECs as airbrakes.
During roll out, at low speed (about 60 knots), the pilot normally disengages the AP by pressing a takeover pushbutton located on the side stick.

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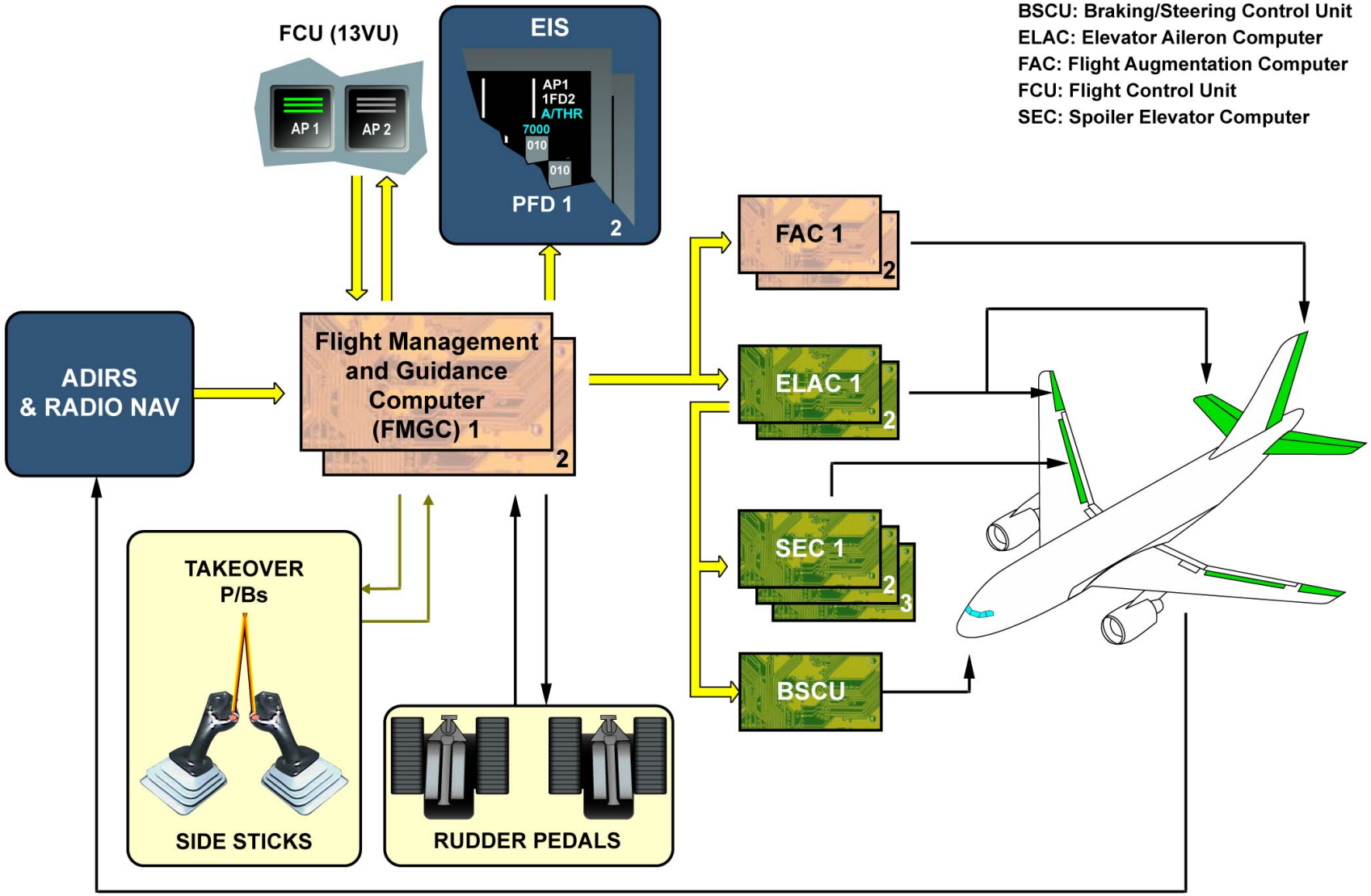

GENERAL ... LANDING

FLIGHT DIRECTOR PRESENTATION (2)

ENGAGEMENT

The Flight Director (FD) functions are engaged automatically as soon as the system is electrically supplied and logic conditions are fulfilled.
FD engagement is indicated on the Flight Control Unit (FCU) by the FD P/BSW green bars and on the top right of each PFD. 1FD2 indication is displayed on each PFD to show that FD1 is engaged on the CAPT side and FD2 is engaged on the F/O side.

NOTE: On ground, as long as no AP/FD mode is active, there are no FD symbols on the PFDs.

PRINCIPLE

The FD displays the Flight Management and Guidance Computer (FMGC) guidance commands on both PFDs. In manual flight, the FD displays guidance orders to help the pilots to apply commands on the controls in order to follow the optimum flight path, which would be ordered by the AP if it was engaged. When the AP is engaged, the FD helps the FMGC demands to be checked.
The FD modes are the same as the AP modes and are selected the same way. The FMGCs calculate AP/FD orders which are transformed into symbols by the Display Management Computers (DMCs). There are two types of symbols: the FD bars, the Flight Path Director (FPD) and Flight Path Vector (FPV) symbols. The central HeaDinG-Vertical Speed (HDG-V/S)/TRacK-Flight Path Angle (TRK-FPA) P/BSW on the FCU makes the pilots switch between these two types of symbols.

FD PUSHBUTTONS

Upon FCU power up, in go around, or when losing the AP during the roll out phase of the landing, the three green bars of the FD P/BSWs come on automatically. A lit FD P/BSW means that the FD symbols can be displayed on the corresponding PFD: PFD 1 for the CAPT FD P/BSW and PFD 2 for the F/O FD P/BSW. If a lit FD P/BSW is pressed, the green bars go off. Pressing the P/BSW again puts the green bars on again. A non lit FD P/BSW means that no FD symbols can be displayed on the corresponding PFD. -FD2 is displayed on each PFD to show that no FD symbols can be displayed on PFD 1 and FD 2 is engaged on the F/O side.

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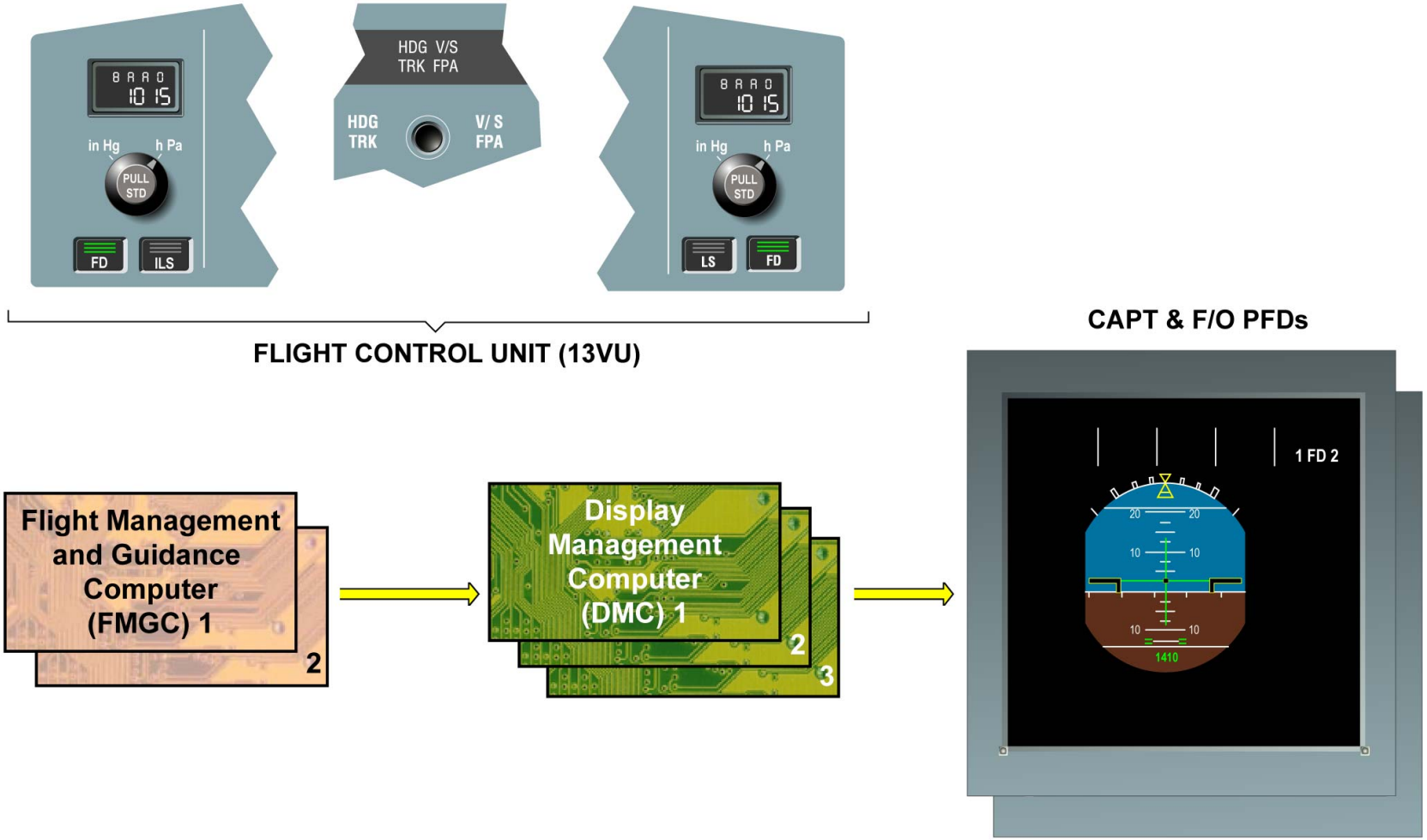

ENGAGEMENT ... FD PUSHBUTTONS

FLIGHT DIRECTOR PRESENTATION (2)

FD BARS

The FD bars can be displayed provided HDG-V/S is selected on the FCU. HDG-V/S is automatically selected at system power up.

NOTE: At certain system configuration changes, the FMGCs send a command to the DMCs to make the FD bars flash for 10 seconds.

AP/FD modes are correctly followed when the FD bars are centered on the fixed aircraft model of the PFDs.
There are three FD bars:
- the pitch bar,
- the roll bar,
- and the yaw bar.

The horizontal pitch bar can be displayed if a vertical mode is active except during the roll out phase of the landing. The vertical roll bar can be displayed if a lateral mode is active. Below 30 feet RA at take-off when a LOCalizer (LOC) signal is available and during landing, the roll bar is replaced by a yaw bar index. This bar is then centered when it is just below the central yellow square.

FPD/FPV SYMBOLS

The FPD and the FPV symbols can be displayed provided TRK-FPA is selected on the FCU.

NOTE: At certain system configuration changes, the FMGCs send a command to the DMCs to make the FPD and FPV symbols flash for 10 seconds.

AP/FD modes are correctly followed when the FPD and FPV symbols are superimposed. The FPD symbol supplies command signals to intercept and fly the lateral and vertical flight path as defined by the FMGCs. The FPD symbol is removed if no guidance mode is provided by the FMGCs. The FPV symbol represents lateral and vertical flight path information in terms of current track and FPA actually being flown. The FPV symbol position is computed by the Air Data Inertial Reference System (ADIRS).

NOTE: The yaw bar is identical to the FD bar case and appears with the same conditions.

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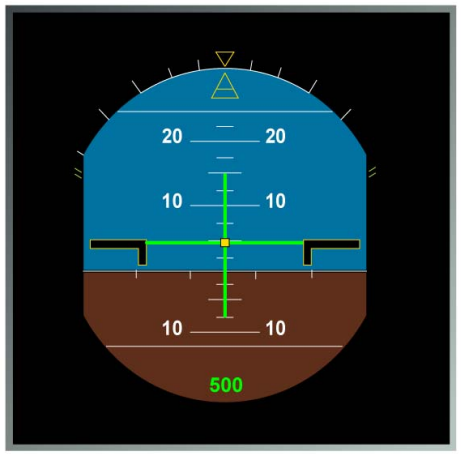
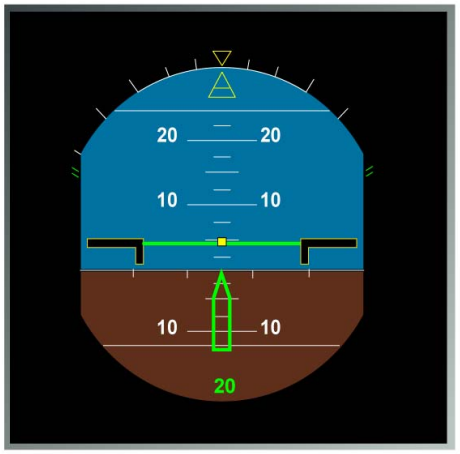
FLIGHT DIRECTOR (FD) BARS

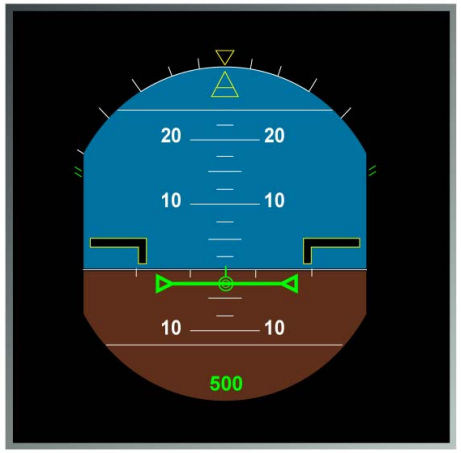


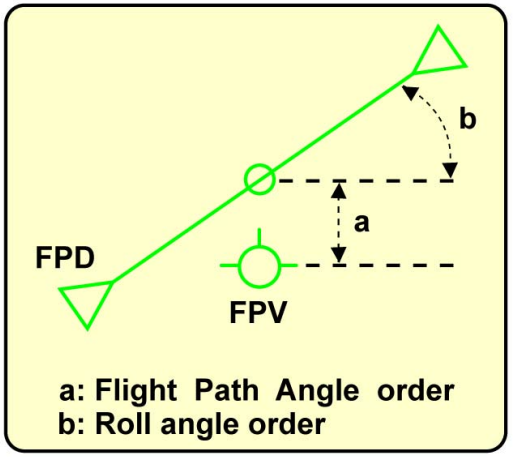
PITCH AND ROLL BARS



PITCH AND YAW BARS

FLIGHT PATH DIRECTOR/ FLIGHT PATH VECTOR (FPD/FPV) SYMBOLS





FD BARS & FPD/FPV SYMBOLS

AUTOTHRUST PRESENTATION (2)

AUTOTHRUST FUNCTION

The A/THR function sends a computed thrust command (thrust target) to the Full Authority Digital Engine Control (FADEC) for automatic engine control.
The A/THR functions are:
- acquisition and holding of a speed or a Mach number,
- acquisition and holding of a thrust,
- reduction of the thrust to idle during descent and during flare in final approach,
- protection against excessive Angle-Of-Attack (AOA) called alpha-floor protection, by ordering a maximum thrust when an alpha-floor detection signal is received from the Flight Augmentation Computers (FACs).

AUTOTHRUST LOOP PRINCIPLE

To get the A/THR function, the thrust target computed by the Flight Management and Guidance Computers (FMGCs) is chosen by the Flight Control Unit (FCU). Then each FCU processor sends, along its own bus, the thrust target to the FADEC via the Engine Interface Units (EIUs).

AUTOTHRUST ENGAGEMENT

The engagement of the A/THR function can be manual or automatic. The A/THR is engaged manually by pressing the A/THR P/BSW on the FCU. This is inhibited below 100 feet RA, with engines running.
The A/THR is engaged automatically:
- when the AP/Flight Director (FD) is engaged in Take-Off (TO) or Go Around (GA) modes,
- or in flight, when the alpha-floor is detected; this is inhibited below 100 feet RA except during the 15 seconds following the lift-off.

NOTE: To effectively have A/THR on the engines, the engagement of the A/THR is confirmed by a logic of activation in the FADEC.

When A/THR is engaged:
- the FCU A/THR P/BSW is lit,
- the engagement status is displayed on the Flight Mode Annunciator (FMA).

When engaged, the A/THR can be active or not depending on the position of the thrust levers. When engaged and not active, the thrust control is manual. The thrust is commanded according to the position of the thrust levers. When engaged and active, the thrust control is automatic. The thrust is commanded according to the A/THR computed thrust target.

AUTOTHRUST DISCONNECTION

A/THR disengagement can be manual or automatic.
A/THR is manually disconnected:
- either by pressing the A/THR instinctive disconnect switch on any thrust lever,
- or by setting all thrust levers to idle position,
- or through the dedicated FCU P/BSW,

A/THR is automatically disconnected in case of failure detection.

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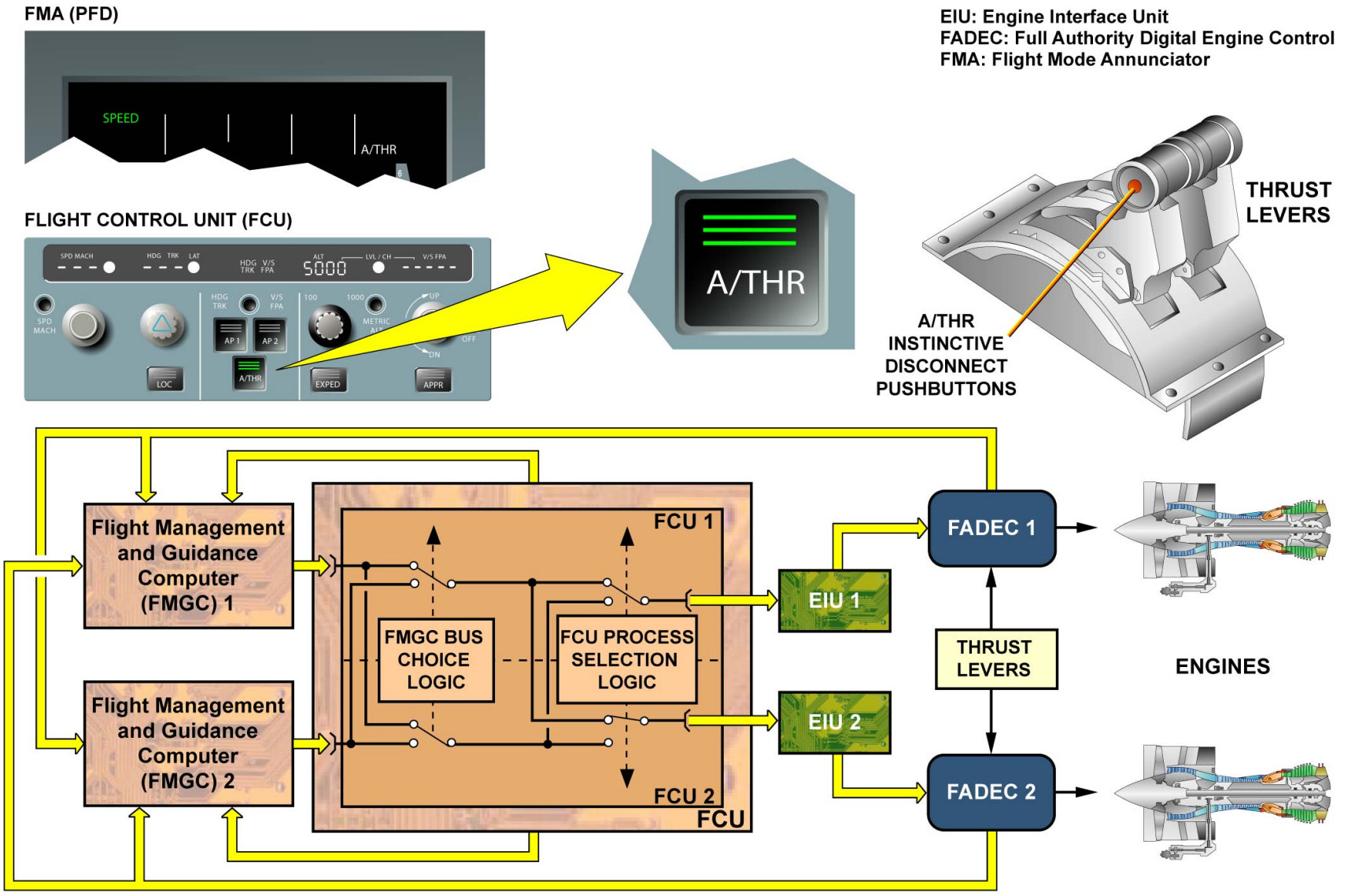

AUTOTHRUST FUNCTION ... AUTOTHRUST DISCONNECTION

AUTO FLIGHT SYSTEM CONTROL & INDICATING (2)

LOCATE CONTROL/INDICATING IN THE COCKPIT

FCU/MCDU/ECP

SIDE STICKS/THRUST LEVERS

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AUTOMATIC FLIGHT SYS MAINTENANCE SYSTEM D/O (3)

GENERAL

The Auto Flight System (AFS) is a type 1 system, ables to maintain a two-way communication with the Centralized Fault Display Interface Unit (CFDIU). The line maintenance of the AFS is based on the use of the Fault Isolation and Detection System (FIDS) active in the Flight Augmentation Computer (FAC) 1 and of the BITEs located in the various AFS computers. Access to the fault data is made through the Multipurpose Control and Display Units (MCDUs) via the CFDIU. Like for other systems, the CFDIU works in NORMAL mode and MENU mode (See ATA 31-CFDS).

FIDS

The FIDS is a card physically located in each FAC. Both FACs are interchangeable, but only the FAC 1 FIDS is active due to the side 1 signal. The FIDS is used as a system BITE to concentrate maintenance information. The FIDS is linked in acquisition and reception to the CFDIU and is connected to the BITEs of the various AFS computers. It receives commands from the CFDIU, interprets these commands and transfers them, if applicable, to the various BITEs concerned. It receives malfunction reports from the BITEs, manages these reports, and, if applicable, consolidates the BITE diagnosis (occurrence, correlation...) and generates a fault message, which is sent to the CFDIU.

NOTE: If the FIDS fails, the BITEs continue to work and the results can be read in the shop or after FAC 1 change.

The NORMAL mode function is the same as in other systems. In addition to the usual system report functions, the MENU mode gives access to GROUND SCAN, AFS TEST and LAND TEST.

BITE

According to its internal architecture, each AFS Line Replaceable Unit (LRU) has one or several BITEs. The basic purpose of a BITE is to detect, isolate, memorize failures, the Flight Control Unit (FCU) and MCDU BITEs only perform the detection task. The failure detection is triggered by specific events listed in the maintenance manual. Example of Flight Guidance (FG) CoMmanD (CMD) triggering event: ILS own failure. The failure localization corresponds to an analysis processed to identify the source of the failure.

FAC/FM/FG BITE

As the FAC and FG have a BITE in the CMD and the MONitor (MON) sides, the fault analysis is generally made on each side and a synthesis is made on the CMD side. Each BITE memorizes the result of the analysis, the failure context, the flight leg number, the time and date of each given failure. Then the BITE sends the result of the analysis, with a maximum of two suspected LRUs in the order of probability, to the FIDS.

FCU BITE

Each FCU BITE computes the maintenance status of its related part and permanently sends this maintenance data to the FG CMD part.

MCDU BITE

The MCDU does the tests on its processor, memory and display unit. If a failure is found by the MCDU BITE:
- the FAIL annunciator comes on and the display is blank,
- the MCDU FAIL output discrete is set and sent to the FM part and then to FG 1 and FG 2 CMD parts through the crosstalk bus.

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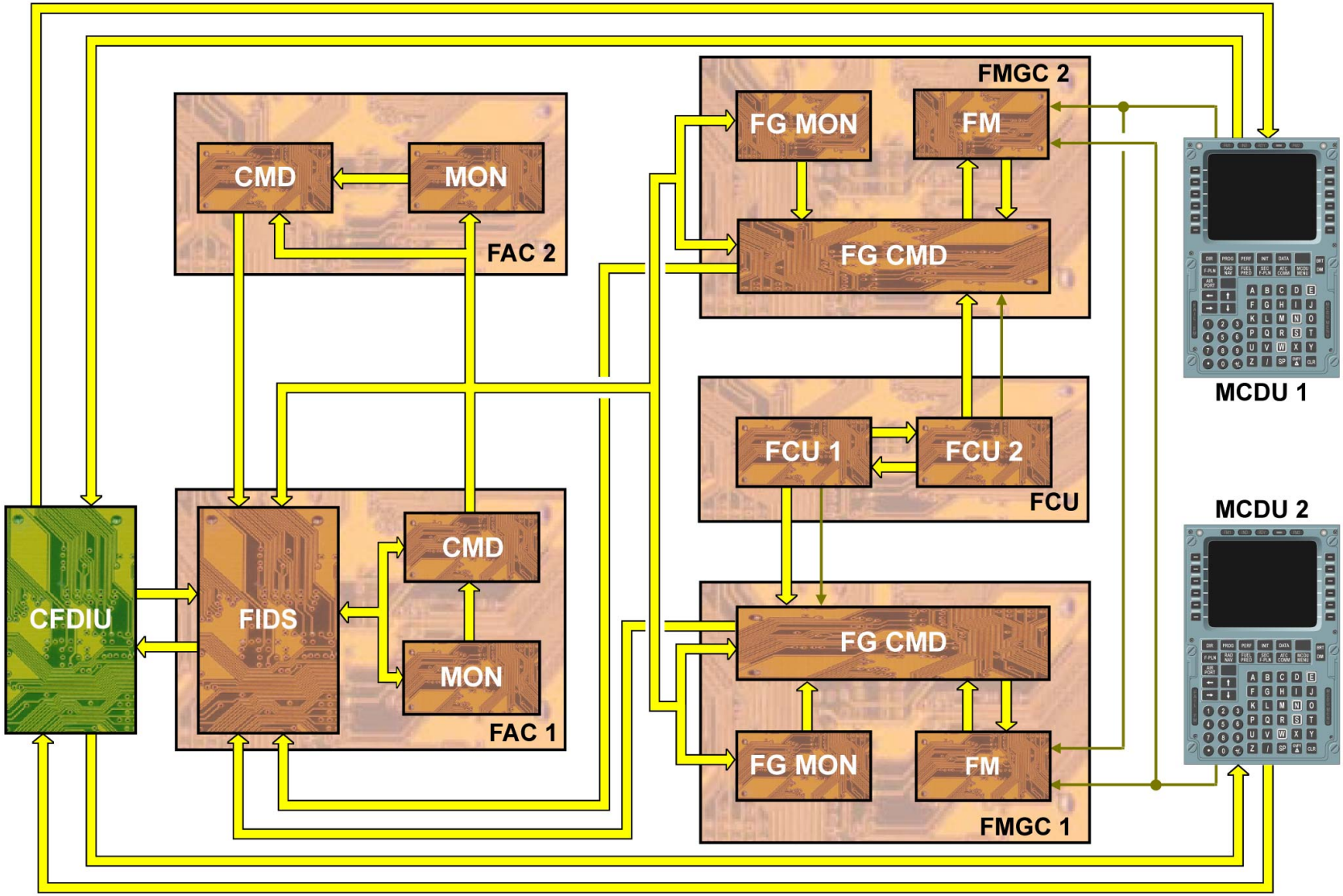

GENERAL ... MCDU BITE

AUTOMATIC FLIGHT SYS MAINTENANCE SYSTEM D/O (3)

GROUND SCAN

The GROUND REPORT function displays failures recorded in the ground area of the FIDS memory. The PRESENT FAILURE SCAN function is used to isolate failures present when the function is selected. The manufacturer for development purposes uses the PROGRAM page.

AFS TEST

An AFS TEST is done:
- to check an AFS LRU before removal,
- to check an AFS LRU after installation,
- to get trouble shooting data (even if the test is OK).

LAND TEST

The LAND TEST gives the test availability of the LANDing mode and equipment required to obtain CATegory 3. There are several successive pages in which actions, checks and answers are requested from maintenance.

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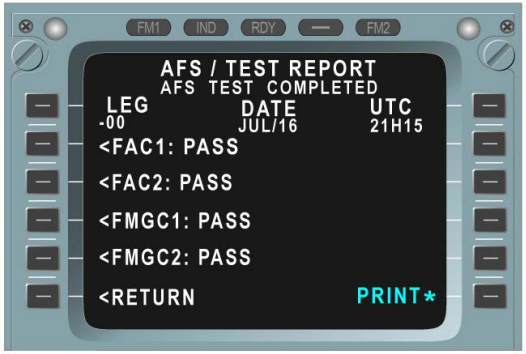
GROUND SCAN



AFS TEST

LAND TEST

GROUND SCAN ... LAND TEST

AUTOMATIC FLIGHT SYS MAINTENANCE SYSTEM D/O (3)

SAFETY TESTS

After long term power interruption, computers and control units of the AFS do the safety tests also called power-up tests. These tests are only done on ground, except for the FCU, which can make safety tests on ground or in flight. During these tests, no action should be done on the system. If a unit does not pass the safety test, it is declared failed and unusable and an ECAM message is displayed on the STATUS page.

NOTE: The recommended conditions to do the safety test are:
. aircraft on ground, engines stopped, hydraulic power (green/yellow) for FAC only,
. pull the C/B of the involved computer (both C/Bs for FCU),
. wait 15 seconds (7 minutes for FCU), and then push the C/B of the involved computer,
. wait 1 minute for safety test execution.

PROCEDURE

This AFS maintenance procedure has to be followed in the event of a pilot report concerning the AFS.

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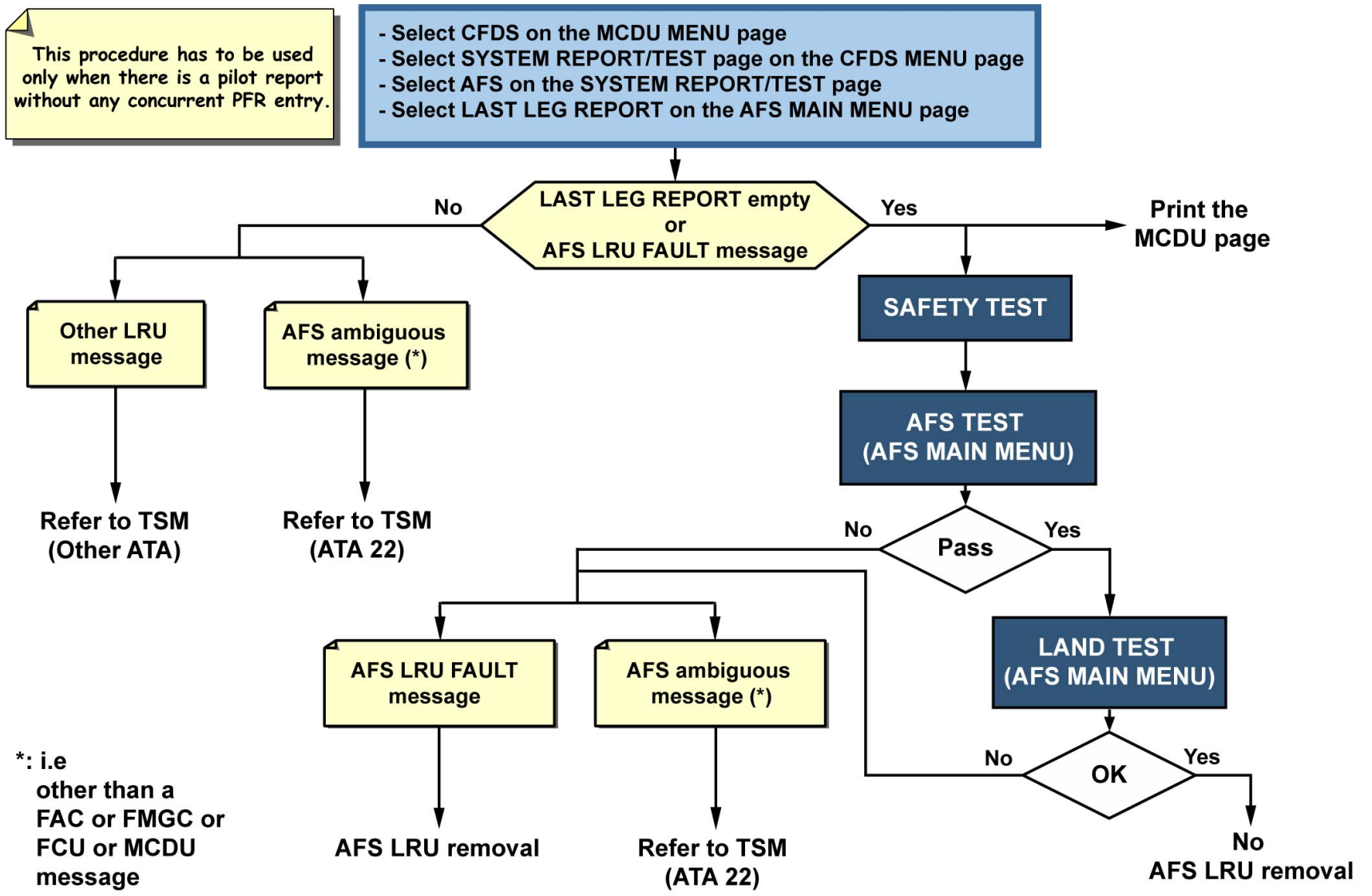
This procedure has to be used only when there is a pilot report without any concurrent PFR entry.
- Select CFDS on the MCDU MENU page
- Select SYSTEM REPORT/TEST page on the CFDS MENU page
- Select AFS on the SYSTEM REPORT/TEST page
- Select LAST LEG REPORT on the AFS MAIN MENU page
LAST LEG REPORT empty or AFS LRU FAULT message
No
Yes
Print the MCDU page
Other LRU message
AFS ambiguous message (*)
Refer to TSM (Other ATA)
Refer to TSM (ATA 22)
SAFETY TEST
AFS TEST (AFS MAIN MENU)
Pass
No
Yes
AFS LRU FAULT message
AFS ambiguous message (*)
AFS LRU removal
Refer to TSM (ATA 22)
LAND TEST (AFS MAIN MENU)
OK
No
Yes
No AFS LRU removal
*: i.e other than a FAC or FMGC or FCU or MCDU message

SAFETY TESTS & PROCEDURE

YAW AXIS CONTROL D/O (3)

YAW DAMPER

When the AP is not engaged, the ELevator Aileron Computer (ELAC) calculates the yaw damper order with the normal law. The yaw damper order calculated by the ELAC provides turn coordination; dutch roll damping and engine failure compensation. If both ELACs fail, only the dutch roll damping (alternate law) is computed by the Flight Augmentation Computer (FAC) using the Air Data Inertial Reference System (ADIRS) data.
When the AP is engaged, the FAC calculates the yaw damper order except in LANDing mode where it is computed by the Flight Management and Guidance Computer (FMGC). When the AP is engaged:
- dutch roll damping law is given by the FAC using ADIRS data.
- engine failure compensation fast law is given by the FAC using the ADIRS data in Take-Off/Go-Around (TOGA) or RunWaY modes only.
- turn coordination law computes the yaw order to the FMGC roll order.
In LAND mode, the FMGC yaw order controls the yaw damper actuators via the FAC.

RUDDER TRIM

The RUDder TRIM selector via the FAC controls the rudder trim in manual mode. In the rudder trim auto mode, the FAC computes the engine failure compensation and the turn coordination. When the AP is engaged:
- the turn coordination law computes the yaw orders related to the FMGC roll order. Signals are simultaneously sent to the rudder trim actuator and the yaw damper actuators.
- the engine failure compensation slow law orders are sent to the rudder trim actuator.

RUDDER TRAVEL LIMITATION

The rudder travel limitation is computed by the FAC and sent to the rudder travel limiting unit. The FAC rudder travel limiting law computes this limit using the calibrated airspeed (Vc) given by the ADIRS.

OPERATION

ELAC NORMAL LAW

This schematic represents the ELAC normal law.

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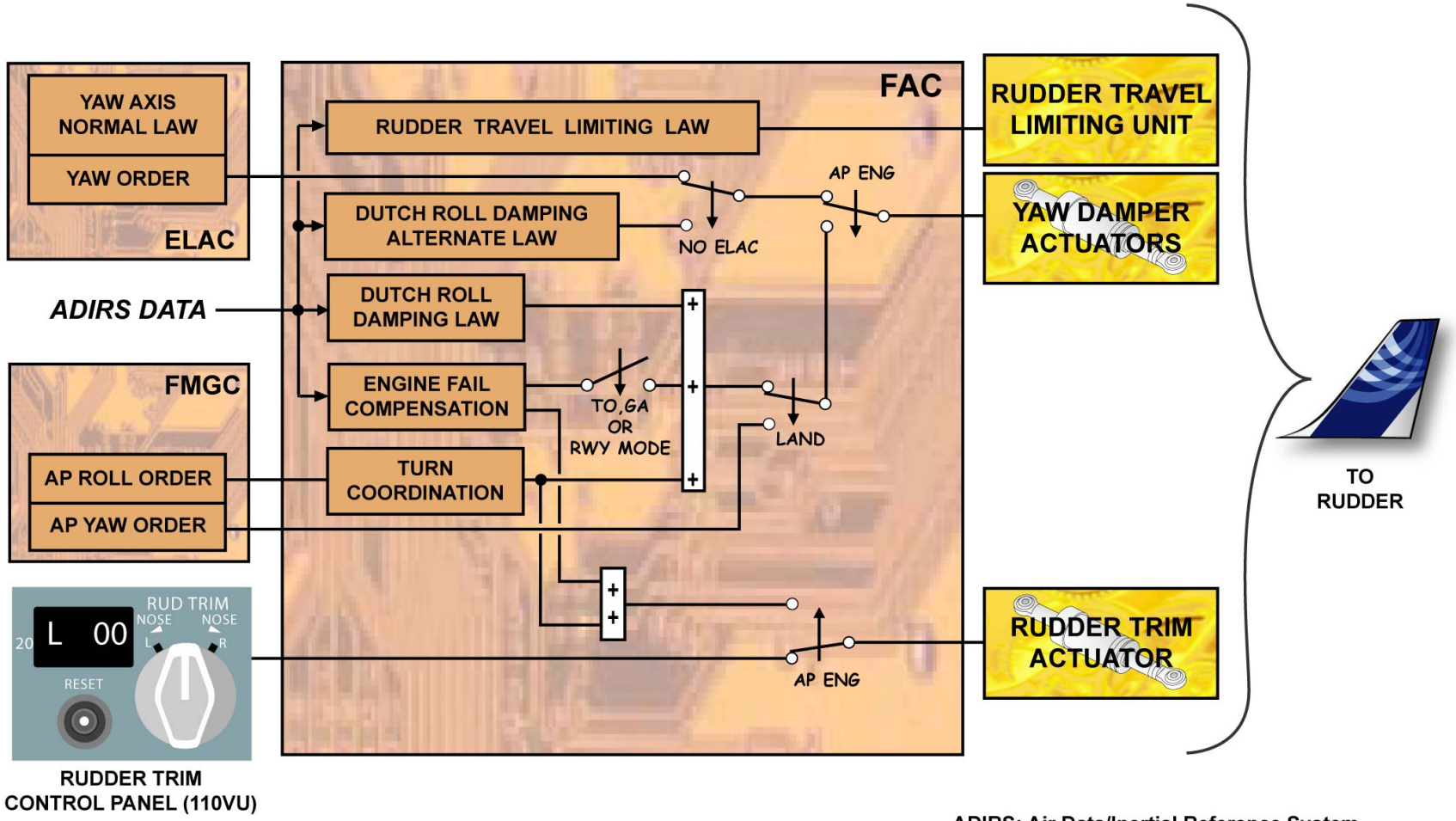

ADIRS: Air Data/Inertial Reference System
AP ENG: Autopilot Engaged
ELAC: ELevator Aileron Computer
FAC: Flight Augmentation Computer
FMGC: Flight Management and Guidance Computer

YAW DAMPER ... OPERATION

YAW AXIS CONTROL D/O (3)

OPERATION (continued)

ELAC FAILED ALT LAW

This schematic represents the ELAC failed ALT law.
If necessary, the ELAC must operate in degraded law on the roll axis.
In degraded mode indicated by the ELAC, the FAC computes the yaw damper function and generates a simplified law of Dutch roll damping (alternate law).

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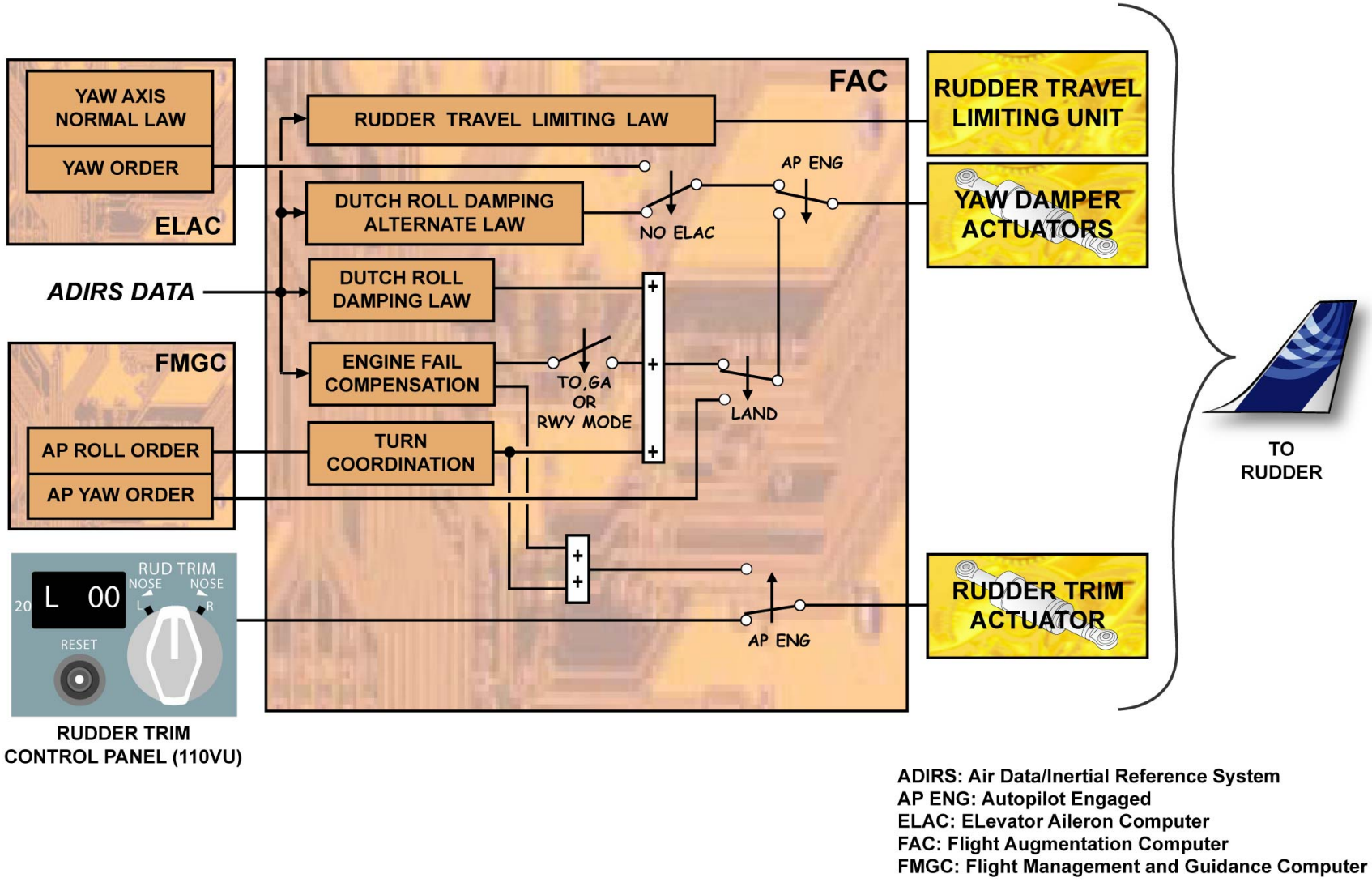

ADIRS: Air Data/Inertial Reference System
AP ENG: Autopilot Engaged
ELAC: ELevator Aileron Computer
FAC: Flight Augmentation Computer
FMGC: Flight Management and Guidance Computer

OPERATION - ELAC FAILED ALT LAW

YAW AXIS CONTROL D/O (3)

OPERATION (continued)

AP ENGAGED CRUISE

This schematic represents the AP engaged cruise.
As soon as the AP is engaged, the yaw damper operates in the mode given below:
- Dutch roll damping
- Turn coordination to reduce the sideslip in turn as a product of the roll order from the FMGC.

Additionally, for the rudder trim operation in automatic mode the autopilot has priority thus, the manual pilot trim is not possible in AP engaged configuration. The order for rudder trim deflection is a product of the turn coordination and (in the event of an engine failure) engine fail compensation. The AP also provides signals which validate the detection of engine failure as a function of the engine rating. In all cases the rudder trim deflection is always indicated on the rudder trim control panel.

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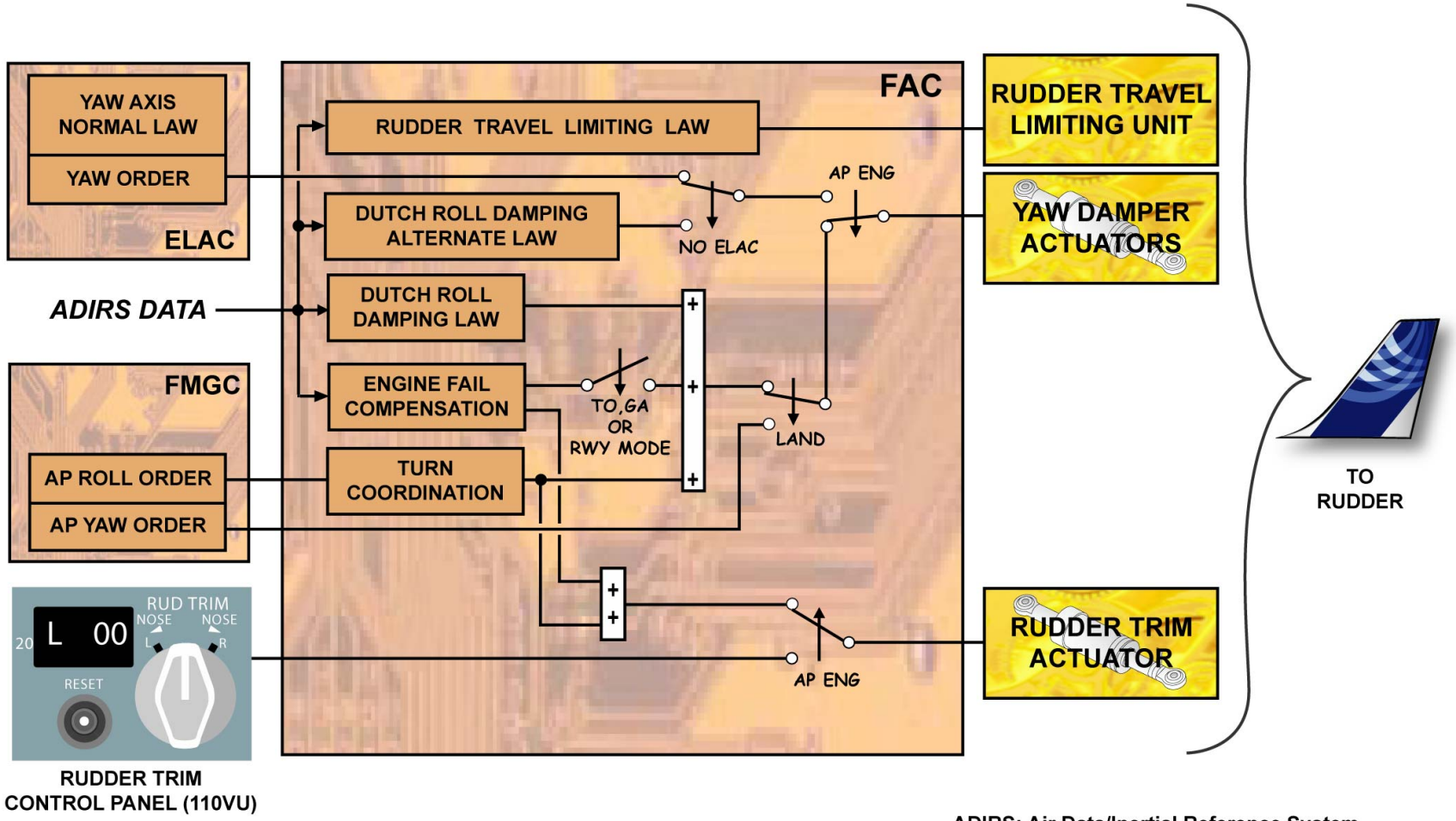

ADIRS: Air Data/Inertial Reference System
AP ENG: Autopilot Engaged
ELAC: ELevator Aileron Computer
FAC: Flight Augmentation Computer
FMGC: Flight Management and Guidance Computer

OPERATION - AP ENGAGED CRUISE

YAW AXIS CONTROL D/O (3)

OPERATION (continued)

AP ENGAGED ENGINE COMP TOGA/RWY MODE

This schematic represents the AP engaged engine comp TOGA/RWY mode.

As stated priviously stated, as soon as the AP is engaged, the yaw damper operates in the mode given below:

- Dutch roll damping
- Turn coordination to reduce the sideslip in turn as a product of the roll order from the FMGC.

In TOGA/RWY mode the yaw damper will now include engine failure compensation in the event of an engine failure.

This mode provides lateral guidance function, at takeoff, on the runway centerline by means of the LOC beam and by following an optimum longitudinal flight path after rotation.

This mode is available:

- for the FD during takeoff run and in flight
- for the AP 5 seconds after lift-off.

The mode is engaged when the pilot selects the takeoff thrust by positioning the throttle control levers beyond the MCT/FLX TO gate.

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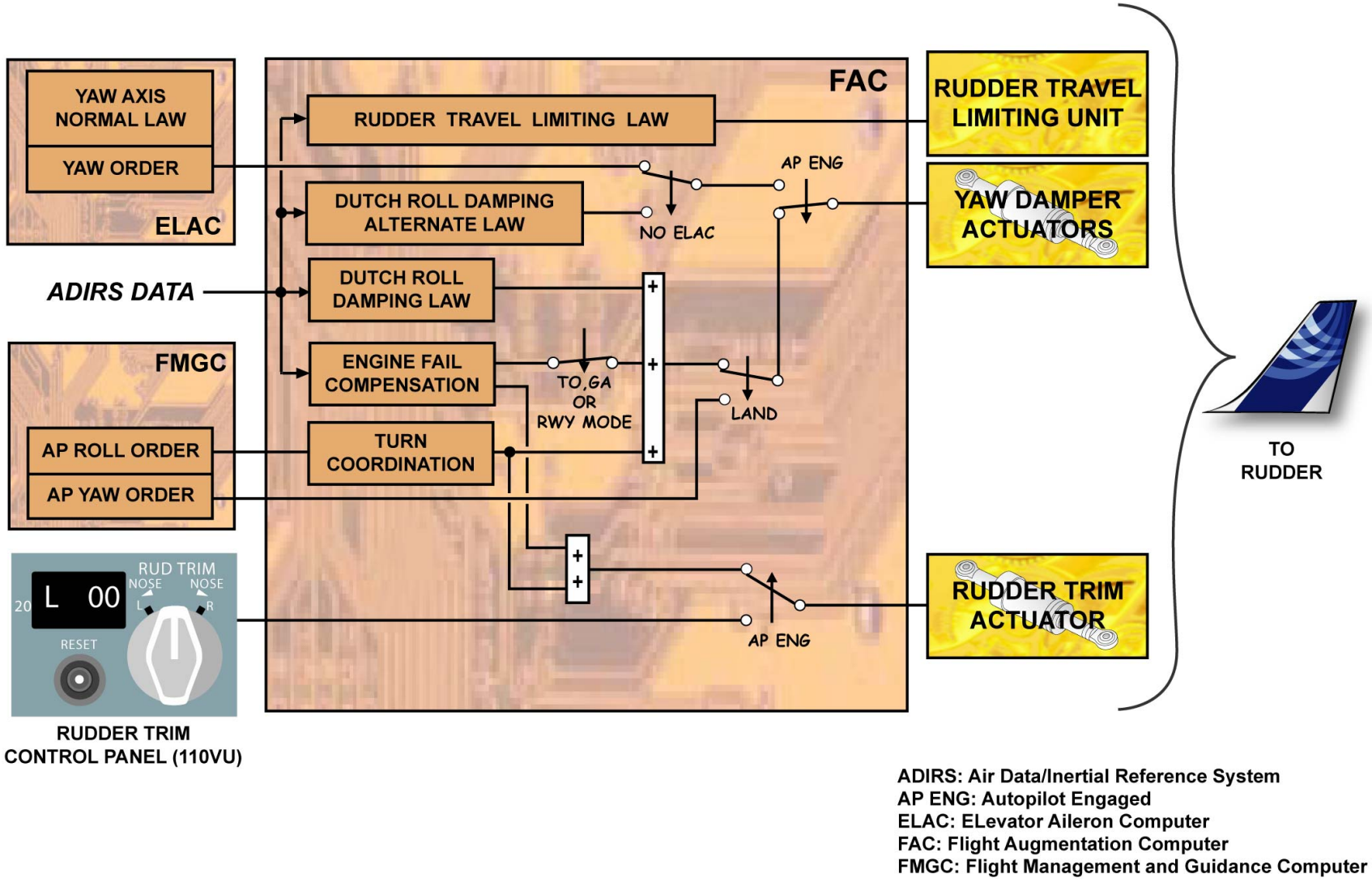

ADIRS: Air Data/Inertial Reference System
AP ENG: Autopilot Engaged
ELAC: ELevator Aileron Computer
FAC: Flight Augmentation Computer
FMGC: Flight Management and Guidance Computer

OPERATION - AP ENGAGED ENGINE COMP TOGA/RWY MODE

YAW AXIS CONTROL D/O (3)

OPERATION (continued)

AP ENGAGED LAND MODE

This schematic represents the AP engaged LAND mode. With the autopilot engaged and the Land Mode activated, Dutch roll damping and Turn coordination are inhibited and yaw damping is accomplished directly from the FMGC yaw guidance order.

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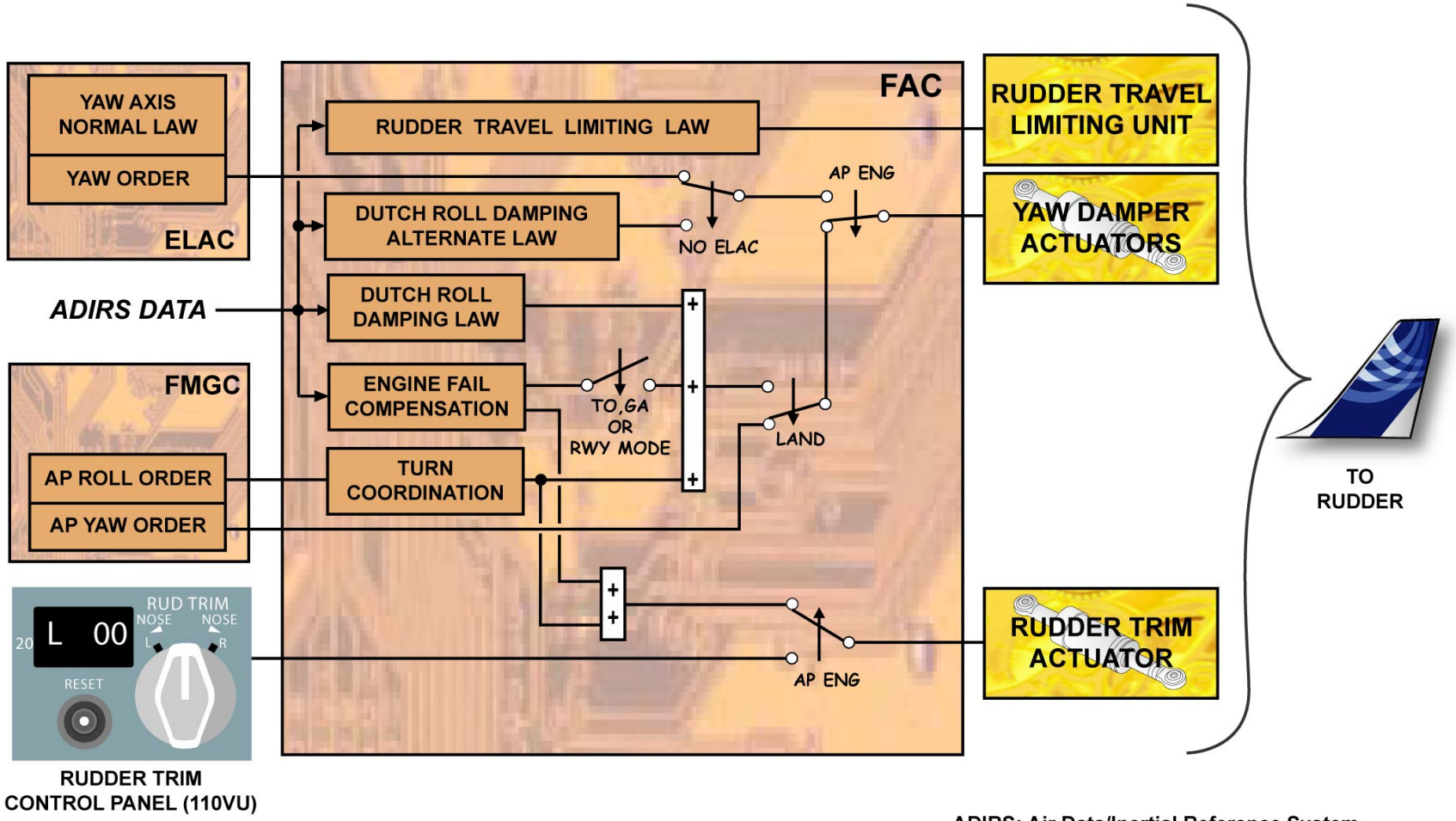


ADIRS: Air Data/Inertial Reference System
AP ENG: Autopilot Engaged
ELAC: ELevator Aileron Computer
FAC: Flight Augmentation Computer
FMGC: Flight Management and Guidance Computer

OPERATION - AP ENGAGED LAND MODE

FAC ENGAGEMENT D/O (3)

NORMAL CONFIGURATION

In normal configuration, when the Flight Augmentation Computer (FAC) P/BSW is pressed in, the FAULT and OFF lights are off, provided the internal monitoring channels are in good condition and the engagement request is present. When the FAC P/BSW is released out, the FAC is disengaged and the white OFF light comes on.

NOTE: The FAC cannot be engaged on ground after power up during the 30 second test. The amber FAULT light flashes.

FAC NOT ENERGIZED OR NOT installed

If the FAC is not energized and the P/BSW is pressed in, the FAULT light is on with an amber message on the ECAM.

SUBFUNCTION FAULT

If one or several yaw axis control functions fail, only the amber message appears on the ECAM. The FAULT light remains OFF. If one or more of the following functions fail:
- yaw damper,
- rudder trim,
- rudder travel limitation.

Only the amber message appears on the ECAM display unit. The FAC remains engaged.

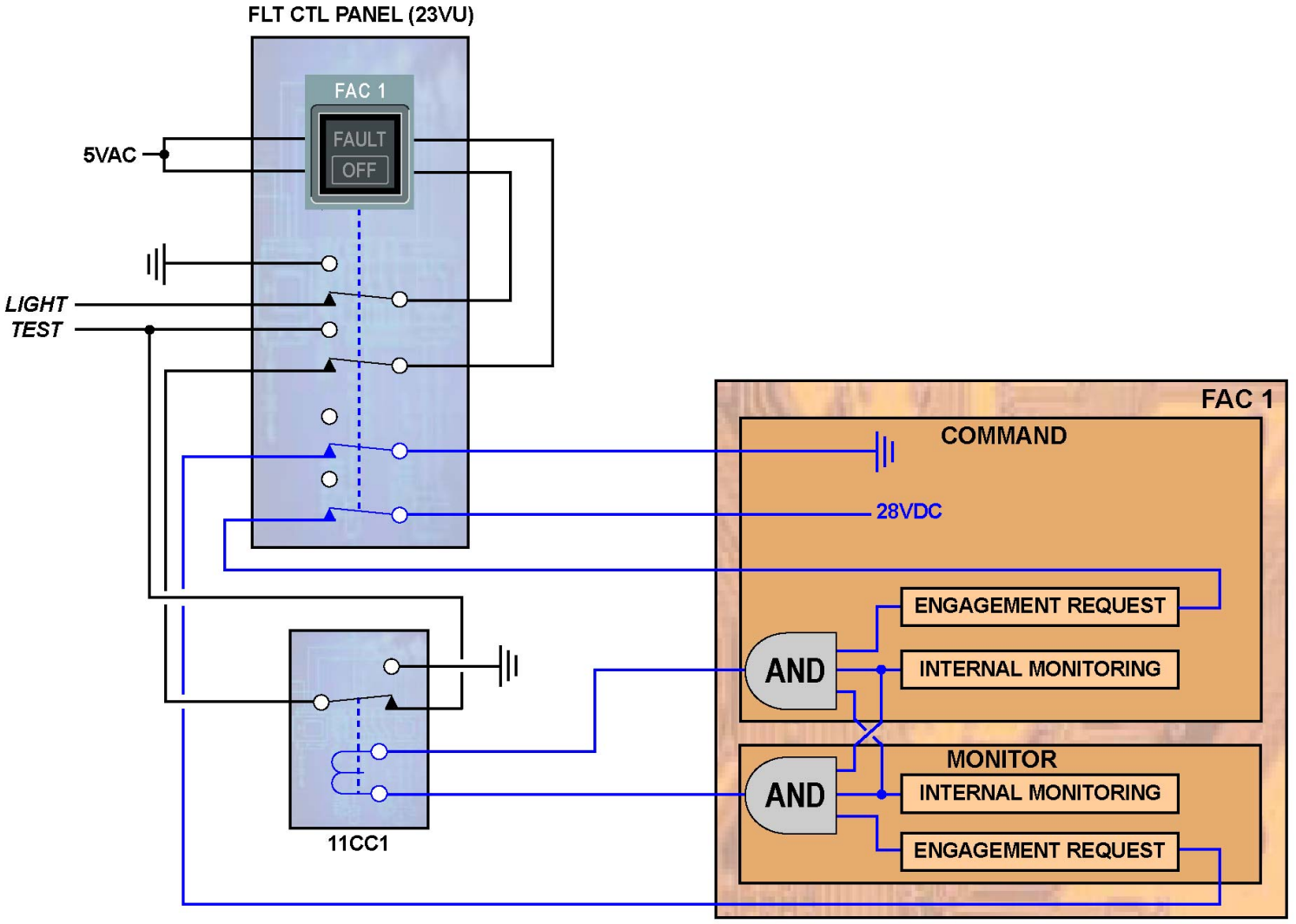
COMPUTER FAULT

When the computer itself fails, the FAC is disengaged and the FAULT light comes on with a message on the ECAM. In this case, a FAC reset must be attempted following the ECAM procedure.

NOTE: On ground with engines shut down, the reset is automatic when the fault disappears.

TEMPORARY POWER LOSS

If a temporary power loss occurs, the FAULT light comes on with a message on the ECAM. In flight, only the reset is possible by using the FAC P/BSW.



NORMAL CONFIGURATION ... TEMPORARY POWER LOSS

YAW DAMPER FUNCTION D/O (3)

COMPONENTS

There are two yaw dampers. In normal operation, both are engaged but only one is active. Yaw damper 1 has priority. The yaw damper function is achieved by:
- 2 electro-hydraulic actuators with an external centering element. Each actuator comprises 1 jack, 1 Linear Variable Differential Transducer (LVDT), 2 solenoid valves, 2 selector valves, 1 pressure switch and 1 Servo Valve (SV).
- 2 Flight Augmentation Computers (FACs).
- 2 Rotary Variable Differential Transducers (RVDTs).

GENERAL

Yaw damper 1 and 2 operate with the changeover logic. The yaw damper actuator does not move the rudder pedals. The yaw damper function operates as follows:
- order is computed by the laws and sent to the rudder via the related yaw damper actuator.
- yaw damper actuator 1 is powered by the green hydraulic system.
- yaw damper actuator 2 is powered by the yellow hydraulic system.

MANUAL MODE

In manual mode, the AP is not engaged and the ELevator Aileron Computer (ELAC) sends to the FAC:
- the turn coordination,
- the dutch roll damping,
- the engine failure compensation yaw orders.

MANUAL ALTERNATE

After a dual ELAC failure, turn coordination and engine failure compensation are lost. Only a simplified alternate law of dutch roll damping is computed by the FAC.

AUTO MODE

In AUTOmatic mode, the FAC computes the dutch roll damping in clean configuration, the engine failure compensation in Takeoff/Go-Around (TOGA) and RunWaY modes. The turn coordination law is computed by using roll orders from the Flight Management and Guidance Computer (FMGC).

LAND MODE

When the LANDing mode is engaged, the yaw order is computed directly by the FMGC.

POWER LOOP

The yaw damper laws control the SV, and the changeover logic controls the two solenoids S1 and S2, which in turn control the selector valves (H). S1 and S2 when powered, move the internal hydraulic parts to a position, which makes it possible for the SV to operate the output jack. If one of the selector valves fails or the signal from the FAC 1 fails, the hydraulic Press switch sends a fail signal to the changeover logic, which then transfer the operation to YD 2. The feedback in the power loop is given by an LVDT for the command side and a RVDT for the monitor side. In case of dual yaw damper loss, a centering spring rod moves the rudder to the neutral position.

MONITORING

At power up, the yaw damper function safety tests are initiated. The continuity between the standby yaw damper and its SV is tested. The computation is monitored by the comparators between command and monitor part. The ELAC, FMGC and Air Data/Inertial Reference System (ADIRS) peripheral inputs are always monitored. The power loop is monitored by a comparator between the yaw order and the rudder position

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feedback. In flight, the hydraulic pressures are monitored by the FAC.
The LVDTs and the RVDTs are always monitored.

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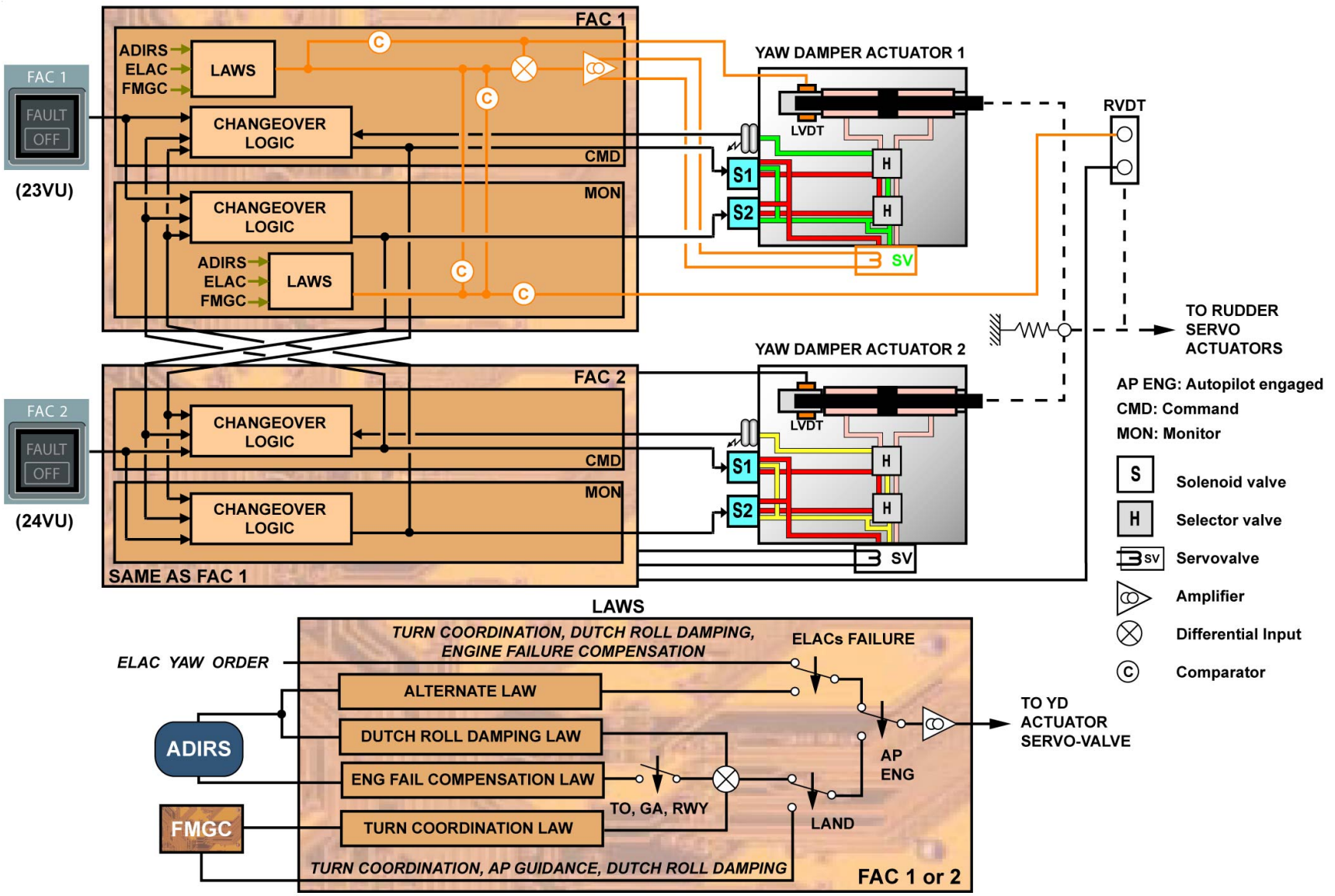

COMPONENTS ... MONITORING

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FLIGHT ENVELOPE PROTECTION D/O (3)

GENERAL

The function of the Flight Augmentation Computer (FAC) is independent of the FAC engagement P/BSW. This function gives:
- characteristic speeds on the PFDs through the Display Management Computers (DMCs),
- the speed limits to the Flight Management and Guidance Computers (FMGCs) for autoflight,
- the alpha-floor detection to the FMGCs for A/THR engagement, if it is not engaged,
- low energy awareness.

The FAC also computes the weight and the center of gravity.

SPEED COMPUTATION DISPLAY

The speeds computed by the FAC are sent to the PFD and the speed limits to the FMGCs. In normal operation, FAC 1 data are displayed on the CAPT PFD and the FAC 2 data on the F/O PFD. If a parameter or the computer fails, the associated PFD is automatically switched to the opposite FAC by the DMC. If the air data source used by the FAC is different from the data source used by the DMC for speed display, the message ADR DISAGREE appears on the ECAM.

SPEED COMPUTATION

Aerodynamic laws and the aircraft configuration parameters are used for the characteristic speed computation. The computation principle is based on the fact that most of the speed data are a function of the aircraft weight. In flight, the FAC computes the weight with the Air Data/Inertial Reference System (ADIRS), FMGC and Slat Flap Control Computer (SFCC) parameters and then, from the weight, it computes the characteristic speeds and the Center of Gravity (CG). On the ground, the FAC uses the weight given by the FMGC.

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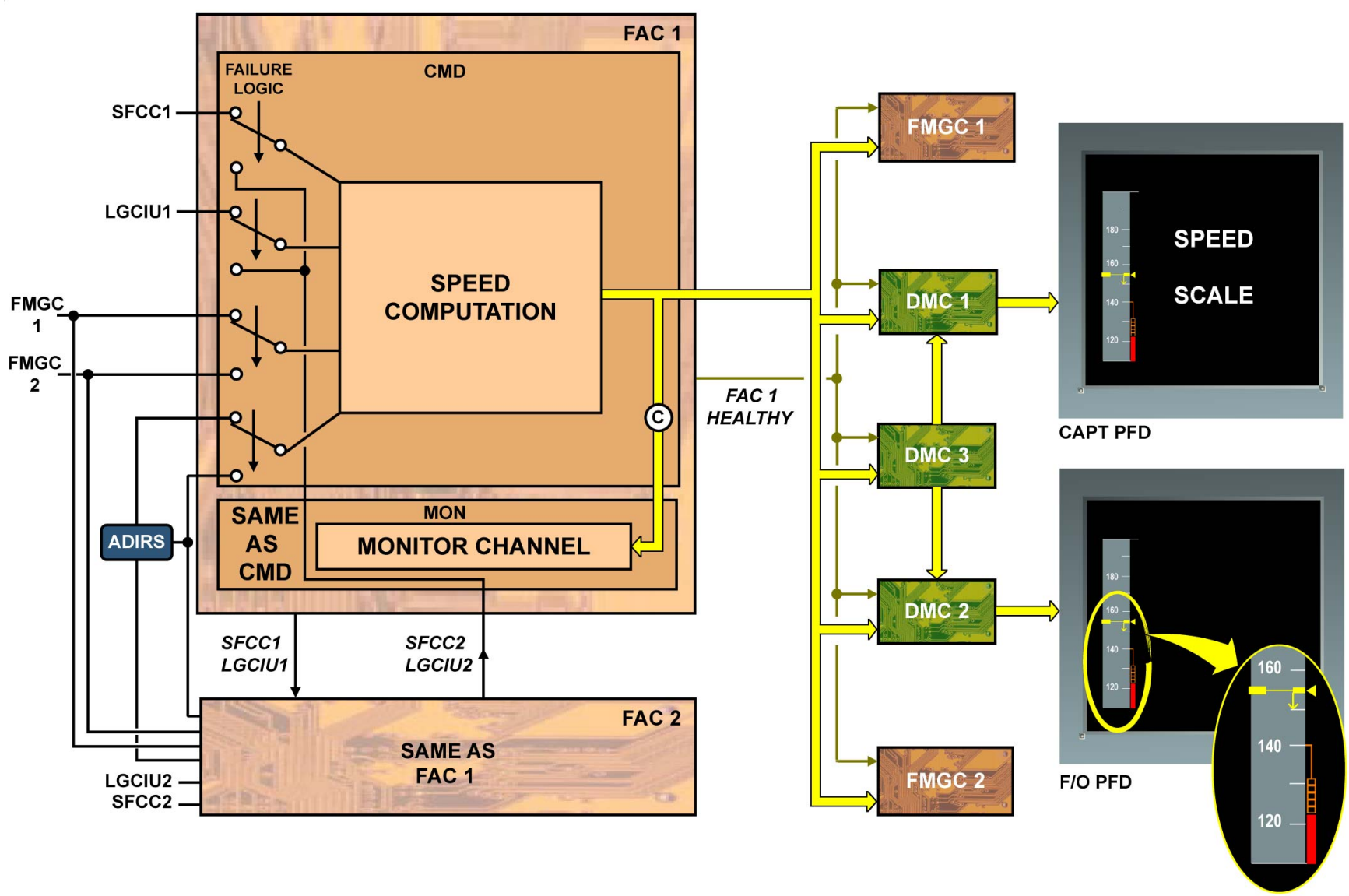

GENERAL ... SPEED COMPUTATION

FLIGHT ENVELOPE PROTECTION D/O (3)

ALPHA-FLOOR AND WINDSHEAR PROTECTION

Alpha-floor detection and windshear protection are computed by the FAC or the ELevator Aileron Computer (ELAC) and sent to the FMGC. This function is a protection of the aircraft against excessive Angle-Of-Attack (AOA). The FAC compares the aircraft AOA (alpha) with the predetermined threshold (function of the slat/flap configuration). This threshold is decreased if windshear occurs.

NOTE: If a windshear condition is detected, the red WINDSHEAR message is displayed on the PFD and the audio warning "WINDSHEAR, WINDSHEAR, WINDSHEAR" starts.

If this threshold is exceeded, the FAC sends a signal to the FMGC to engage the A/THR function and apply full thrust. If the aircraft is in clean configuration, the windshear compensation function is not available. The ELAC will start the alpha-floor protection if one of these conditions occurs:

- alpha protection condition and side stick deflection > 14 degrees,
- pitch angle > 25 degrees and side stick deflection > 14 degrees.

If there is a failure of the two ADIRS, the alpha-floor detection does not operate.

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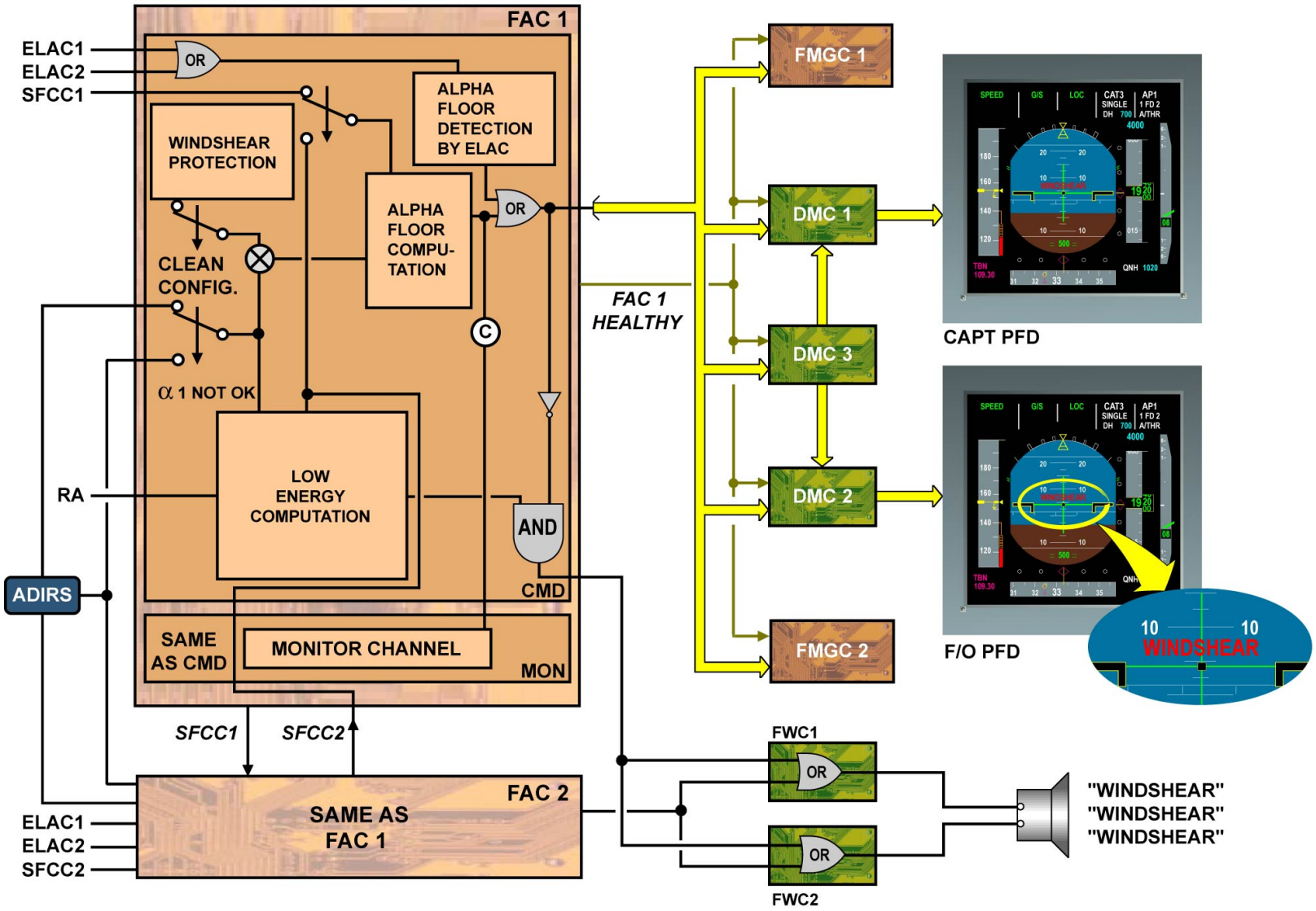

ALPHA-FLOOR AND WINDSHEAR PROTECTION

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FLIGHT ENVELOPE PROTECTION D/O (3)

LOW ENERGY AWARENESS

The energy awareness is a software device which gives the crew an audio warning. This warning tells the crew that it is necessary to increase the thrust to get back a positive flight path angle through pitch control. The audio warning, "SPEED SPEED SPEED", starts before alpha-floor in relation to the AOA, to the configuration deceleration rate and to the flight path angle. It is inhibited when RA is greater than 2000 ft or when alpha-floor is active or when the aircraft is in clean configuration.

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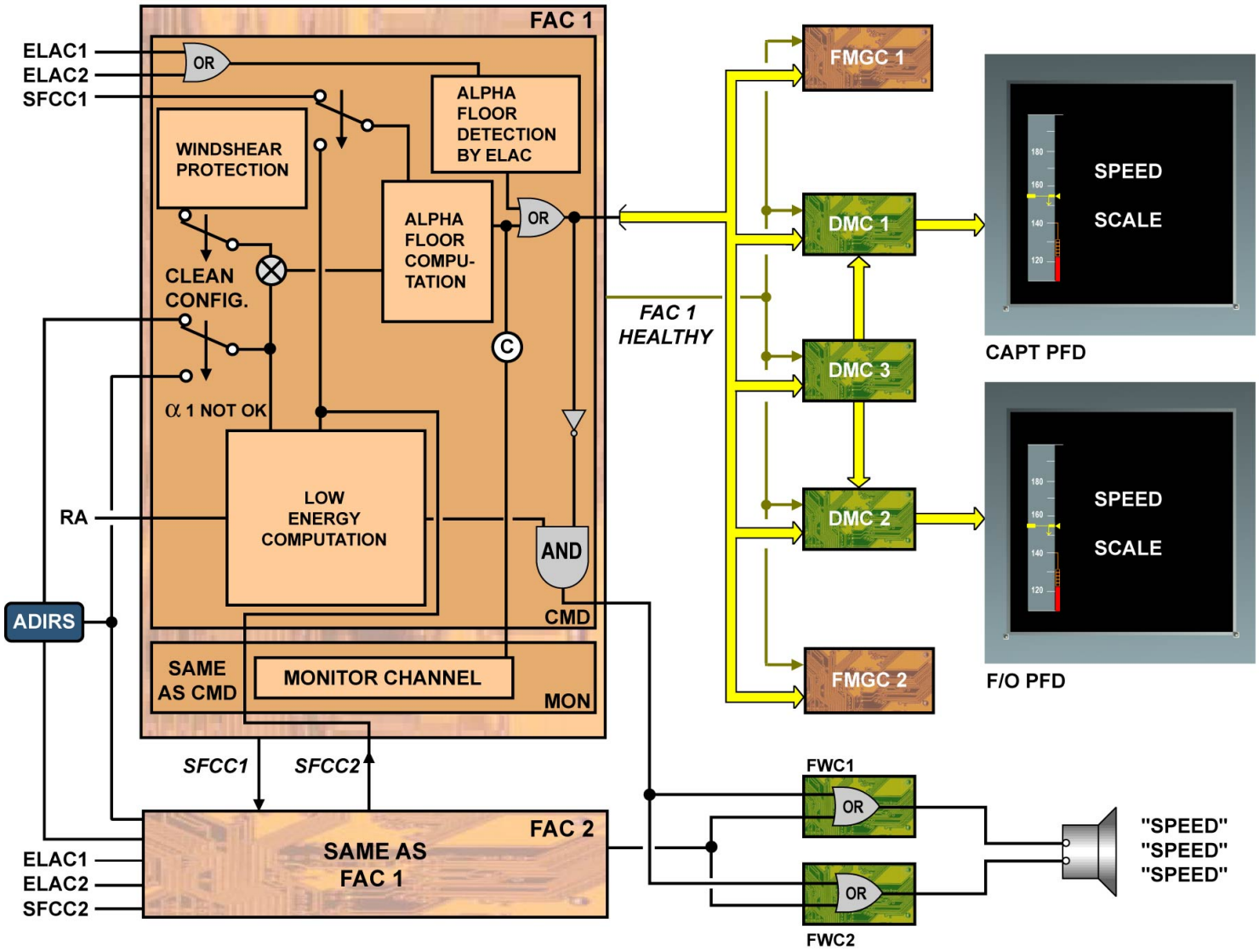

LOW ENERGY AWARENESS

FLIGHT ENVELOPE PROTECTION D/O (3)

TAIL STRIKE PROTECTION (A320/A321)

To decrease the risk of tail strike at landing, a new audio warning, "PITCH-PITCH", is added on A320 and A321 aircraft. This protection function is activated by PIN-Programming on the Flight Augmentation Computers (FACs). On the PFD, below 400 ft, a Vbar symbol is displayed on the pitch attitude scale. It shows the maximum pitch attitude that must not be exceeded during landing to prevent a tail strike.

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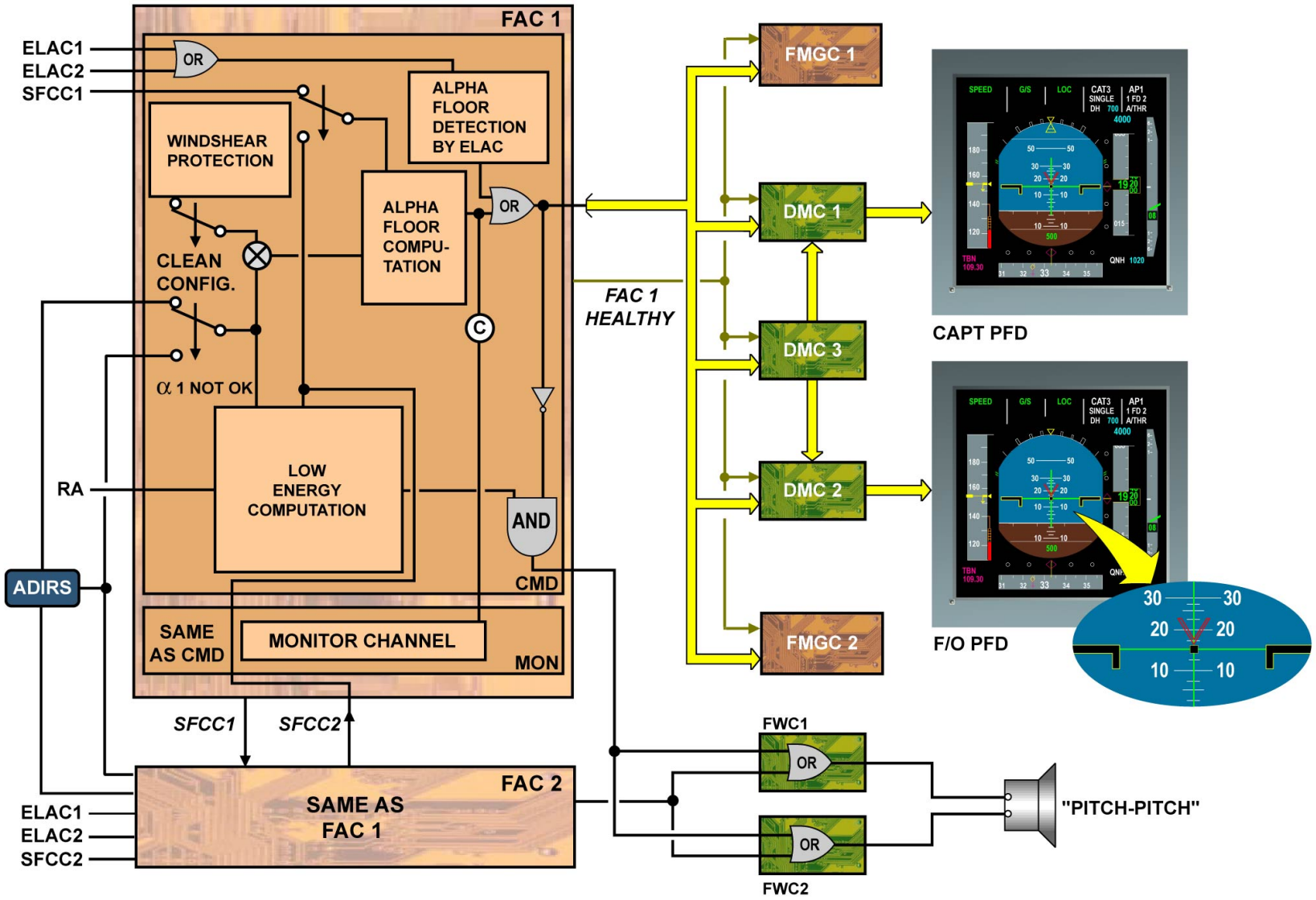

TAIL STRIKE PROTECTION (A320/A321)

FLIGHT GUIDANCE AUTOTHRUST D/O (3)

GENERAL

The A/THR function can be manually engaged from the dedicated P/BSW on the Flight Control Unit (FCU) or automatically when some conditions are fulfilled.

THRUST LEVERS

The thrust levers are manually operated and electrically connected to the Full Authority Digital Engine Controls (FADECs).

NOTE: The thrust levers never move automatically.
Each lever has 3 sectors defined by detents and stops. The thrust levers can be moved on a sector which includes specific positions:
- rear sector: for idle reverse up to max reverse.
- center section:
0: corresponds to an idle thrust,
CL: corresponds to a climb thrust.
- forward section:
FLX/MCT: corresponds to a FLeXible take-off thrust or a Maximum Continuous Thrust after an engine failure,
TOGA: corresponds to a maximum Takeoff/Go Around thrust.
The FADECs compute the thrust limit, which depends on the position of the thrust levers. If both thrust levers are in the same detent, the thrust limit corresponds to this detent. If both levers are not in the same detent, the thrust limit corresponds to the next higher detent. The Flight Management and Guidance Computers (FMGCs) select the highest thrust limits of the FADEC 1 and FADEC 2 for thrust target computation.

A/THR FUNCTION LOGIC

The A/THR function can be ENGAGED or DISENGAGED. When it is engaged, it can be ACTIVE or NOT ACTIVE.

A/THR DISENGAGED

When the A/THR function is disengaged:
- the thrust levers control the engines,
- on the FCU, the A/THR P/BSW light is off,
- the Flight Mode Annunciator (FMA) displays neither the A/THR engagement status nor the A/THR modes.

A/THR ENGAGED AND ACTIVE

When the A/THR function is engaged, A/THR is active if:
- at least, one thrust lever is between the CL detent (included) and the 0 stop (included), and, at the most, one thrust lever is between the FLX/MCT detent and the CL detent, and there is no engine in FLX TO mode,
- or the alpha-floor protection is active independently of the thrust lever positions.

NOTE: In case of one engine failure, the A/THR activation zone is between the FLX/MCT detent and the 0 stop, instead of the CL detent, and the 0 stop.

Because the A/THR function is active:
- the A/THR system controls the engines,
- on the FCU, the A/THR P/BSW light is on,
- the FMA displays the A/THR engagement status in white and the A/THR mode.

A/THR ENGAGED AND NOT ACTIVE

When the A/THR function is engaged, A/THR is not active if:
At least one thrust lever is above the FLX/MCT detent, or both thrust levers are above the CL detent, or at least one engine is in FLX TO mode, with the alpha-floor protection not active.
Because the A/THR function is not active:
- the thrust levers control the engines as long as a thrust lever is outside the A/THR active area,

- the A/THR P/BSW light is on,
- the FMA displays the A/THR engagement status in cyan and the MANual THRust rating in white, surrounded with an amber box.

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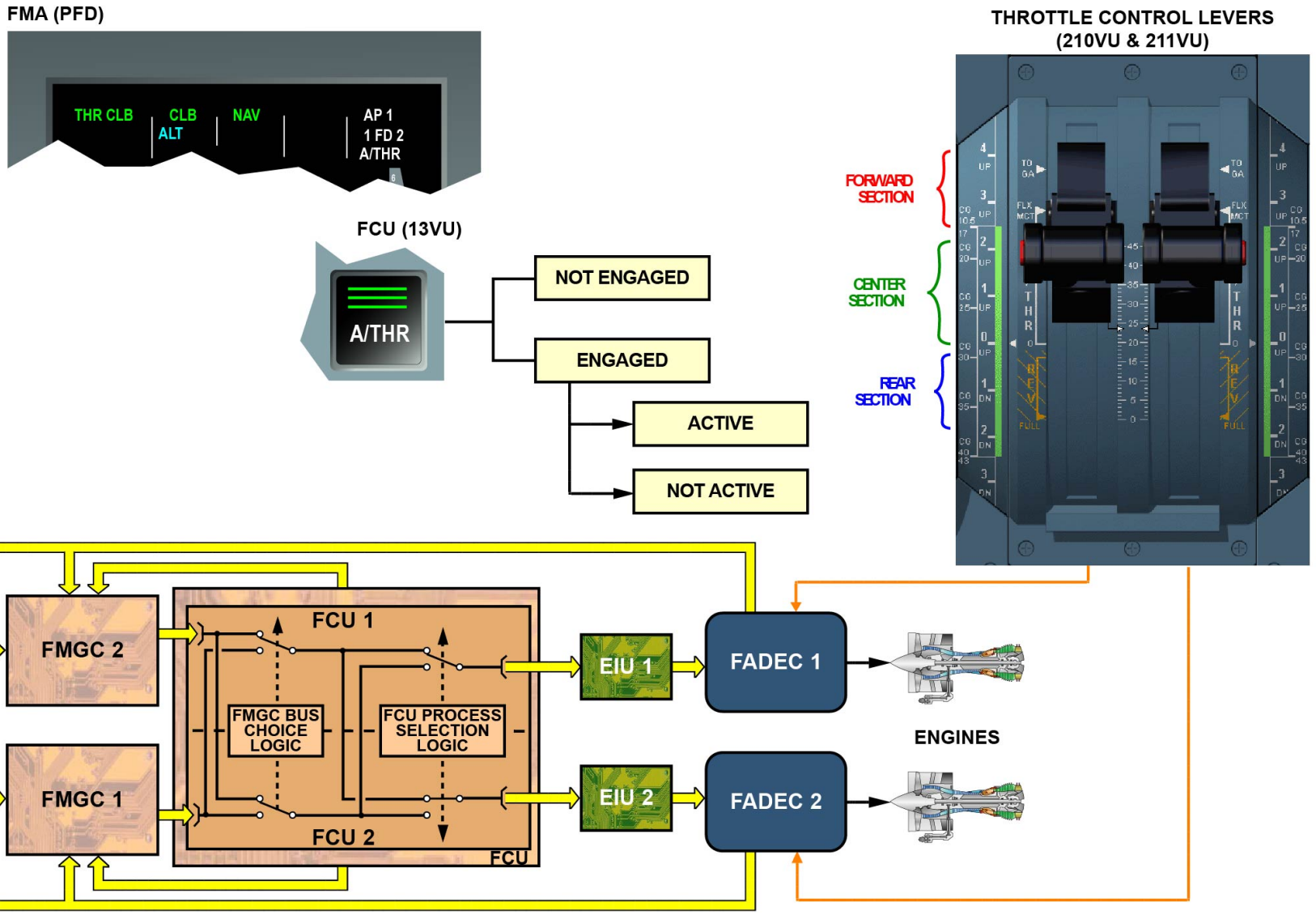

GENERAL ... A/THR FUNCTION LOGIC

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FLIGHT GUIDANCE AUTOTHRUST D/O (3)

MODES

The A/THR function computes a thrust target according to modes and their related reference parameters. The reference can be:
- a speed or a mach number; in this case, the source is either the FCU for a value chosen by the pilot, or the FMGC itself,
- a thrust; in that case, the sources are: The FADECs which compute the thrust limit when the A/THR is not active. The FMGC itself within the thrust limit always computed by the FADECs when the A/THR is active.
The A/THR modes are SPEED/MACH, THR, RETARD, which can be overpassed by the alpha-floor protection.

MODES DESCRIPTION

The choice of the mode is automatically made by the FMGCs according to the active AP or Flight Director (FD) vertical mode. This choice is based on a simple law: priority to the speed control.
- when the AP controls the aircraft speed with the elevators, the A/THR has to control the engines by a fixed thrust demand (THR mode).
- when the AP controls another aircraft parameter (e. g. altitude), the A/THR has to take care of the aircraft speed by a variable thrust demand to the engines (SPEED/MACH mode).
- Beside these two modes, RETARD is only available in automatic landing when engine thrust has to be reduced to idle for the flare phase below 40 feet RA.

DEFAULT MODES

When no vertical mode is engaged, the A/THR operates only in SPEED/MACH modes except:
- when THR mode engages automatically in case of alpha-floor protection activation,
- when, A/THR being in RETARD mode, the AP disengaged, the A/THR function remains in RETARD mode.

ALPHA-FLOOR PROTECTION

The A/THR function protects against an excessive Angle-Of-Attack (AOA). Each Flight Augmentation computer (FAC) detects the alpha-floor signal. In case of excessive AOA or avoidance maneuver, the FACs send an order to the FMGCs which activate the alpha-floor protection. The A/THR automatically engages or stays engaged active and the engine thrust becomes equal to the TOGA thrust for any thrust lever position. In this condition, the green message A. FLOOR with an amber flashing box is displayed on the FMA. When the alpha-floor detection is no longer present in the FACs, the green message TOGA LK (LK for Lock) with an amber flashing box is displayed on the FMA. The alpha-floor protection can only be cancelled through the disengagement of the A/THR function.

A/THR OPERATION IN FLIGHT

TAKE-OFF

The aircraft is on ground and ready for take-off. Neither the AP nor the A/THR are engaged. The engines are controlled by the thrust levers. To take-off, the pilot sets the thrust levers to the TOGA stop or to the FLX/MCT detent if a flexible temperature is selected on a Multipurpose Control and Display Unit (MCDU). This engages the A/THR function but it remains not active.

THRUST REDUCTION ALTITUDE

At the thrust reduction altitude, a message on the FMAs indicates to the pilot that he has to set the thrust levers into the CL detent. As soon as the thrust levers are in the CL detent, the A/THR is active. If a thrust lever is set into the CL-MCT or O-CL area, a message on the FMAs warns the pilot to set the thrust lever to the CL detent:
- white LVR CLB message if it is in the CL-FLX/MCT area,
- amber LVR ASYM message if it is in the O-CL area.

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The A/THR remains active. Then, the thrust levers remain in this position until the approach phase. When the A/C reach the thrust reduction altitude, LVR CLB appears and flashing.

AUTOMATIC LANDING

During automatic landing, before touch down, an auto call out, RETARD, indicates to the pilot that he has to set the thrust levers to the 0 stop. When he does it, the A/THR disengages. This lets the automatic activation of ground spoilers if they are in armed condition. Then, on ground, the pilot moves the thrust levers on the REVerse sector.

DISCONNECTION

Besides the normal A/THR operation, the A/THR function is disengaged either by a pilot action or in case of a system failure. The A/THR function can be disengaged either by pressing at least one of the two red instinctive disconnect P/Bs on the side of the thrust levers or by pressing the A/THR P/BSW on the FCU. A/THR disengagement can also be triggered due to an external system failure. When the A/THR function is active, the actual engine thrust does not necessarily correspond to the thrust lever position.

DISCONNECTION CONSEQUENCES

Consequently, it is important to know what happens after an A/THR disconnection:
When the disconnection is made by the instinctive disconnect P/B, the thrust is immediately adjusted to the thrust lever position.
In other cases, after FCU P/BSW disconnection, or failure:
- when a thrust lever is in its detent, the thrust on the corresponding engine is frozen at its last value just before the disconnection (memo mode).
- as soon as a thrust lever is moved out the detent, or if it is not in a detent, the thrust on the corresponding engine is smoothly adapted to the thrust lever position.

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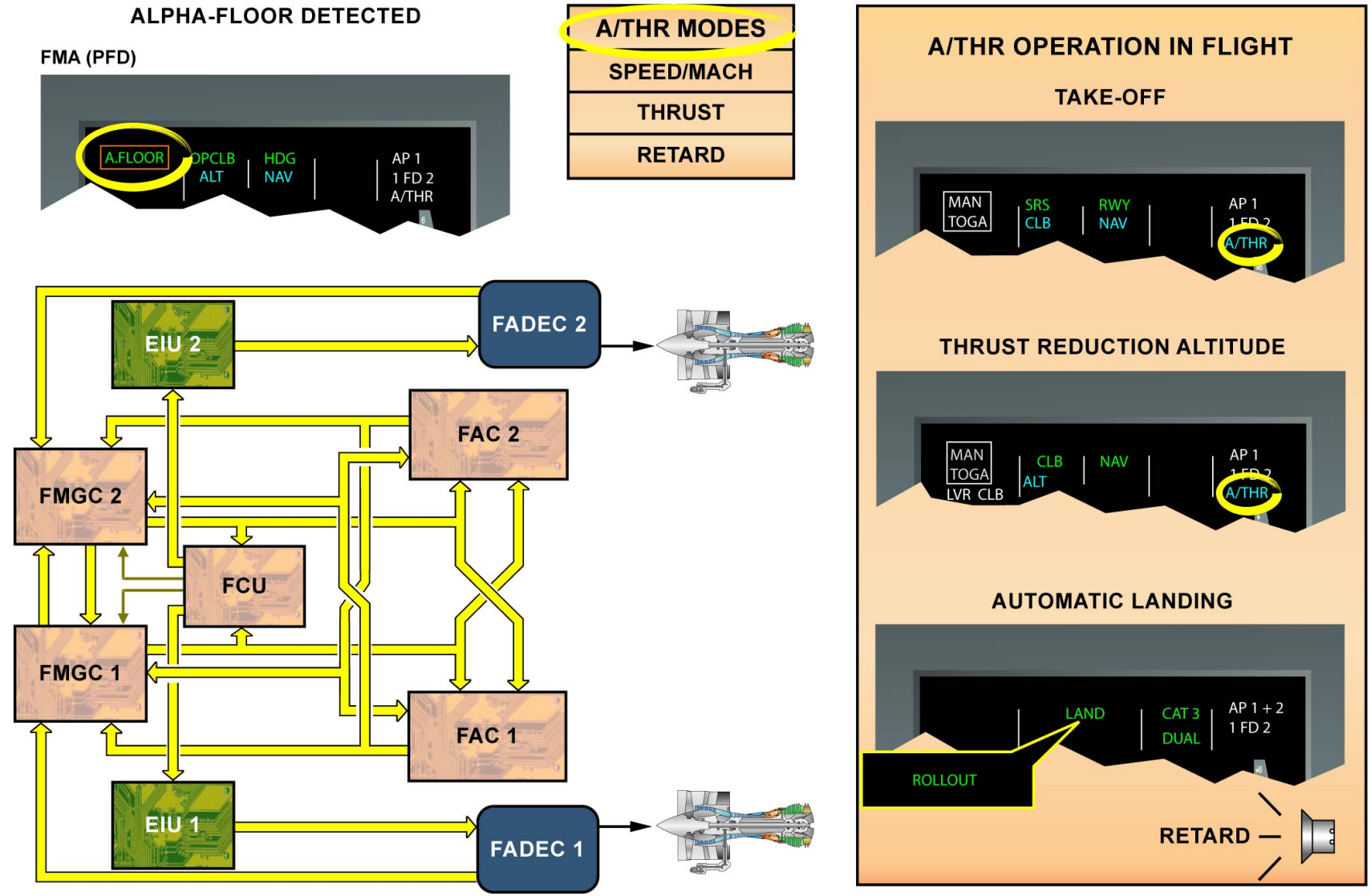

MODES ... DISCONNECTION

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FLIGHT GUIDANCE PRIORITY LOGIC (3)

FLIGHT GUIDANCE

The engagement status of the guidance function works on the master/slave principle. The master Flight Management and Guidance Computer (FMGC) imposes all the changes of AP/Flight Director (FD) modes and/or A/THR engagement to the slave FMGC. Here is an example of a master FMGC. Look at the flow chart to understand the priority logic. With no AP, no FD1 but FD2 engaged, FMGC2 is the master because, by following the flow chart, the first three answers are NO, but the fourth one is YES.

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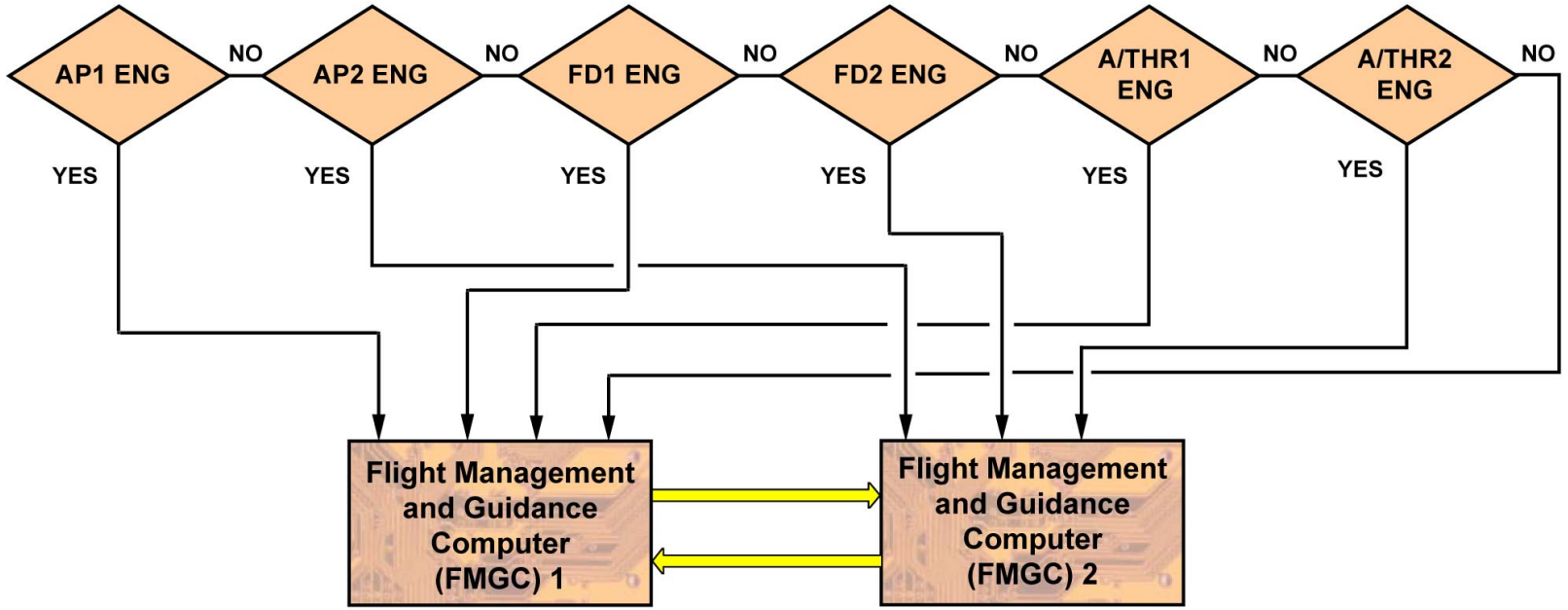
GUIDANCE FUNCTION: FMGC MASTER / SLAVE PRINCIPLE



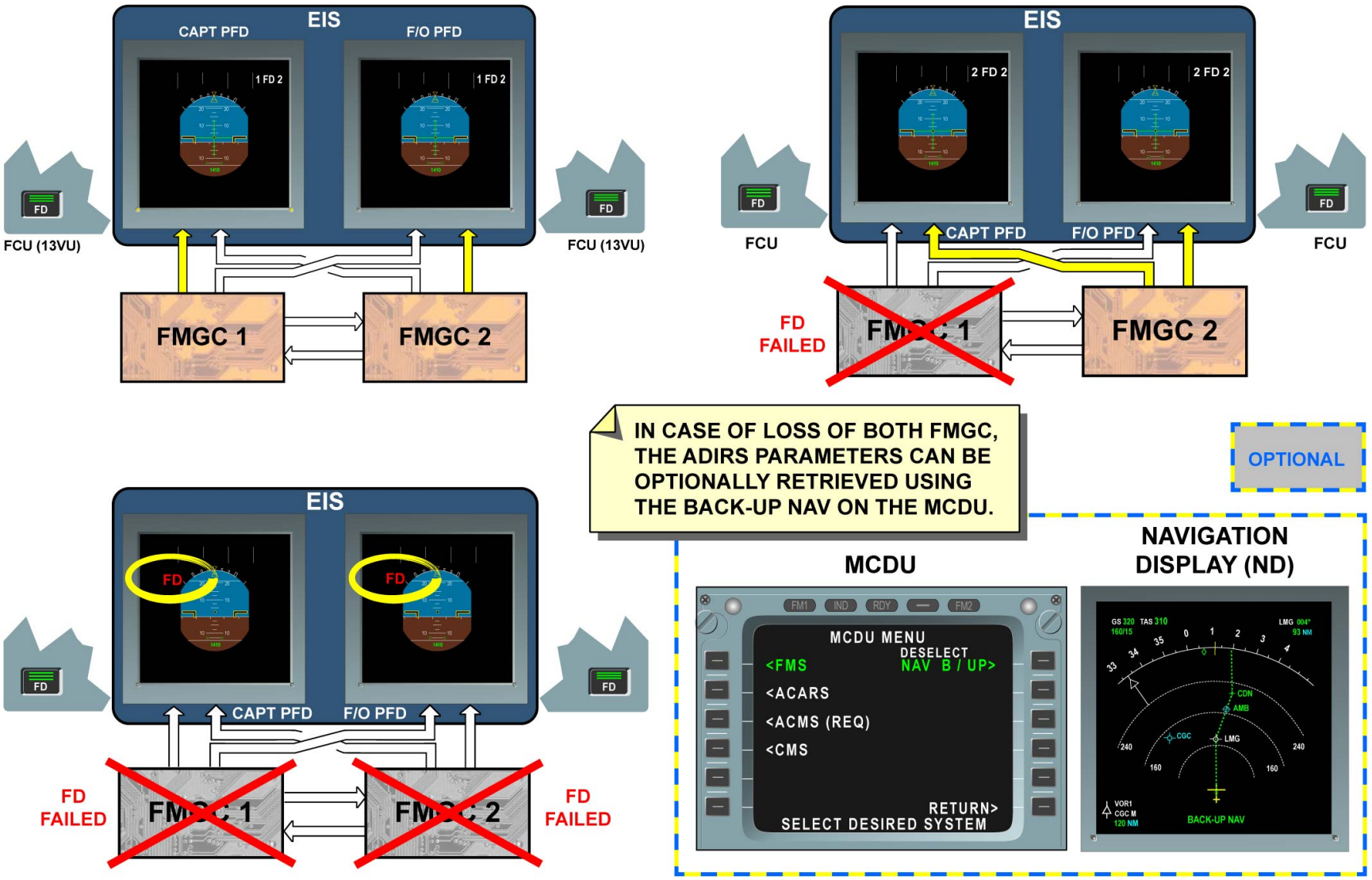
FLIGHT GUIDANCE

FLIGHT GUIDANCE PRIORITY LOGIC (3)

FLIGHT DIRECTOR

At power up, both FDs are normally engaged in split configuration. FMGC1 normally drives the FD symbols (crossbars or flight path director symbols) on the CAPT PFD. FMGC2 normally drives the FD symbols on the F/O PFD. The 1FD2 indication is displayed on each Flight Mode Annunciator (FMA) to show that FD1 is engaged on CAPT side and FD2 is engaged on F/O side. If one FMGC fails, the remaining FMGC drives the FD symbols on both PFDs. If FMGC1 fails, the 2FD2 indication is displayed on each FMA to show that FD2 is displayed on both PFDs. If both FDs fail, a red flag is displayed on each PFD, provided that the corresponding FD switch is on.

NOTE: In case of loss of both FMGC, the ADIRS parameters can be optionally retrieved using the back-up nav on the MCDU.



FLIGHT DIRECTOR

FLIGHT GUIDANCE PRIORITY LOGIC (3)

AUTOPILOT

If one AP is engaged, the corresponding FMGC controls the flight controls through the Flight Control Computers (FCCs). There is no priority logic in single operation. The last engaged AP is the active one. Both APs can be engaged as soon as the APPROACH mode is selected on the Flight Control Unit (FCU). AP1 has priority, AP2 is in standby. The FCCs use the AP1 commands first. A switching is done to the AP2 commands in case of AP1 disengagement.

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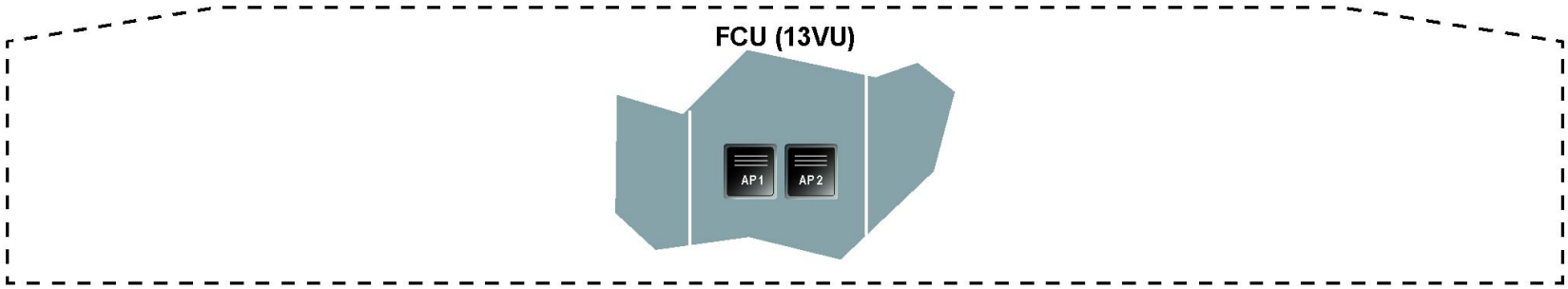
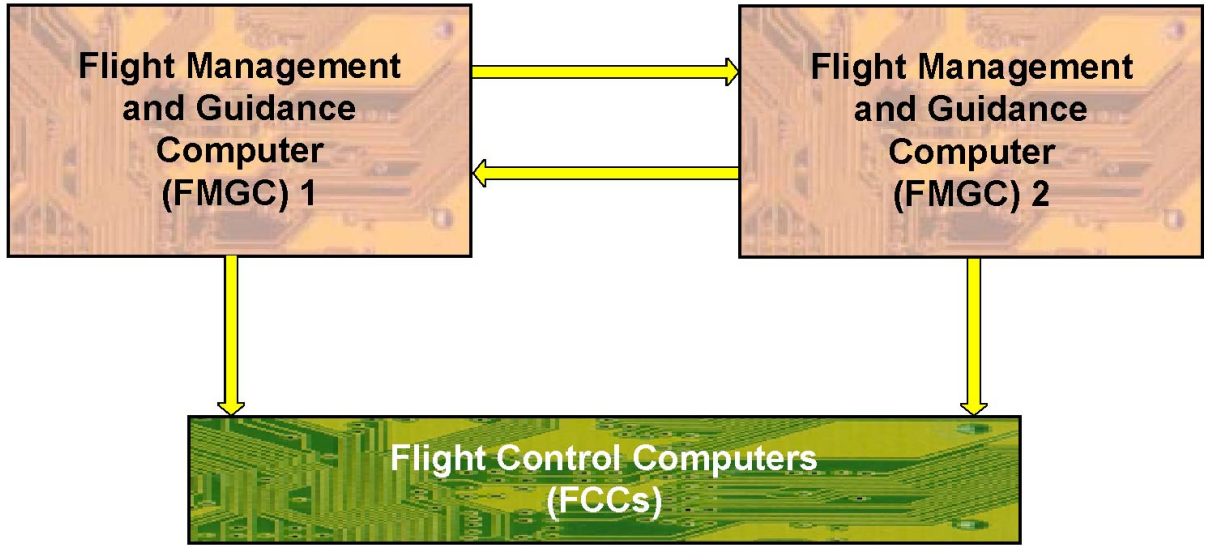

FCU (13VU)
AP1
AP2
AFS CONTROL PANEL


Flight Management and Guidance Computer (FMGC) 1
Flight Management and Guidance Computer (FMGC) 2
Flight Control Computers (FCCs)

AUTOPILOT

FLIGHT GUIDANCE PRIORITY LOGIC (3)

AUTOTHRUST

A single A/THR SW located on the FCU is used for the engagement or disengagement of the A/THR function. The A/THR function is, in fact, composed of two systems (A/THR1 and A/THR2), which are ready to be engaged at the same time, but only one system is selected. However, the selection of A/THR1 or A/THR2 depends on the engagement of the AP and FD. It is done according to the master/slave principle, which is known by the FCU and summarized in the table. When the selected A/THR function is active (according to the thrust lever position), the master FMGC controls the engines, via the FCU. Consequently, in automatic control, it is the same FMGC which controls the engines and the flight controls. To recover the A/THR function, when one AP is engaged and its own A/THR has failed, the opposite AP should be engaged to switch from the master FMGC to the other (which now becomes the master) and to switch to the opposite A/THR.

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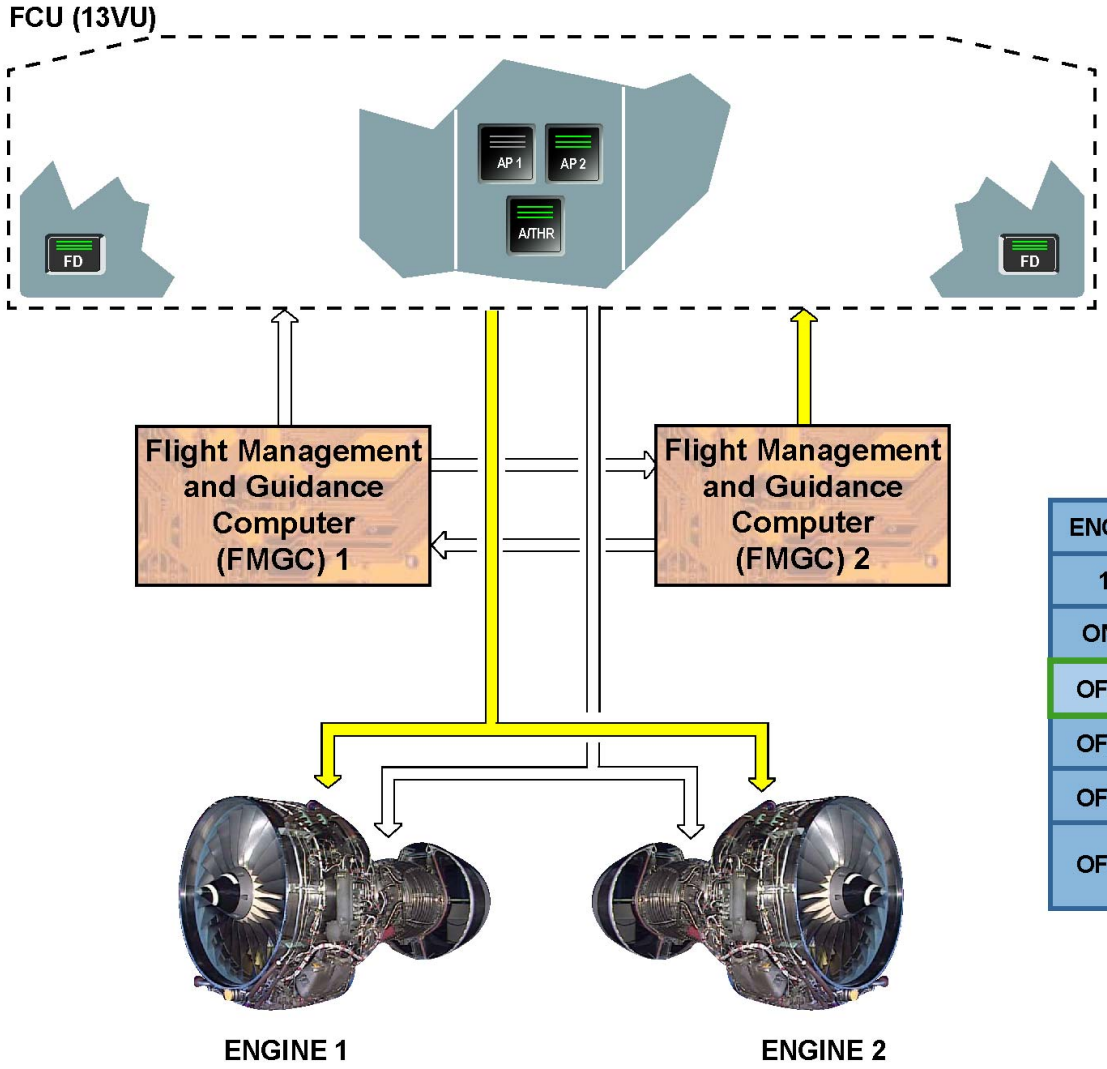

ENGAGT OF AP		ENGAGT OF FD		SELECTED A/THR
1	2	1	2	
ON	*	*	*	A/THR1
OFF	ON	*	*	A/THR2
OFF	OFF	ON		A/THR1
OFF	OFF	OFF	ON	A/THR2
OFF	OFF	OFF	OFF	A/THR1 OR ATHR2 IF ATHR1 FAIL

* ON or OFF

AUTOTHRUST

FLIGHT GUIDANCE PRIORITY LOGIC (3)

FLIGHT MODE ANNUNCIATIONS

The three types of information on the FMA are:
- A/THR mode/status,
- AP/FD mode and status,
- Flight Management (FM) messages.

The master FMGC, which supplies both FMAs, displays the A/THR information. The AP/FD information is displayed according to the following logic:
- with at least one AP, the master FMGC supplies both FMAs,
- without AP, with the FDs engaged, FMGC1 supplies FMA1, FMGC2 supplies FMA2,
- without AP, with one FD failed or manually disengaged, the opposite FMGC supplies both FMAs.

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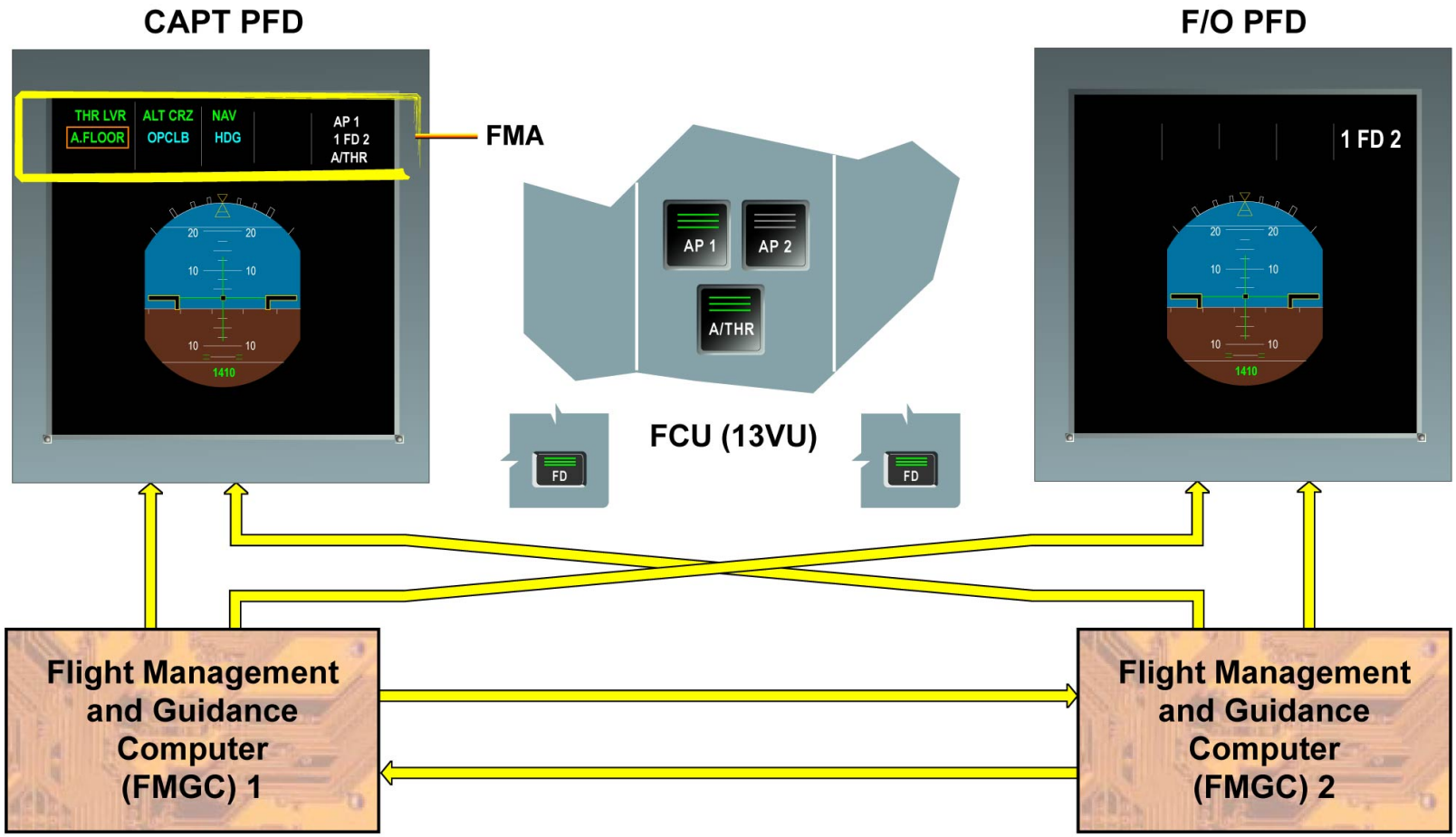

FLIGHT MODE ANNUNCIATIONS

FLIGHT MANAGEMENT PRIORITY LOGIC (3)

fm operating modes

There are three operating modes: NORMAL, INDEPENDENT and SINGLE. At Flight Management (FM) initialization, that means at power up, both FM parts exchange information. Initial cross-comparison is made on the following parameters: Navigation database identification, performance database identification, FM operational program identification, aircraft program pin data and engine program pin data.

NORMAL MODE

If the FM parts agree, normal mode is active. When keys are pressed, they are immediately processed by both FMs, regardless of the Multipurpose Control and Display Unit (MCDU) from which they originate.

INDEPENDENT MODE

If the FM parts disagree, a white message FMS1/FMS2 A/C STS DIFF is displayed on the MCDUs and the system then reverts to independent mode. Each FM part manages its own MCDU. A failure in the Flight Management and Guidance Computers (FMGCs) inter system buses results in an amber MCDU message INDEPENDENT OPERATION.

SINGLE MODE

If one FM part has failed, a single mode is active. Both MCDUs are driven by the remaining FM part. A white message OPP FMGC IN PROGRESS is displayed on the MCDU corresponding to the failed FMGC.

mode operation

NORMAL MODE

In normal mode, the FM part receives the master/slave activation from the Flight Guidance (FG) part. The master computer imposes the following parameters upon the slave computer:
- flight phase,
- flight plan sequencing,
- active performance mode and speeds,
- clearance and maximum altitudes,
- ILS frequencies and courses, if any.

After a flight plan change, there is a comparison on the active leg and, every second, on the active performance mode and active guidance mode. If it is different, the slave computer will synchronize itself to the master computer by copying the master values. Also, aircraft position, Gross Weight (GW) and target speeds from master and slave computers are compared every second.
If the difference is greater than 5 Nm, 2 tons or 2 Kts respectively, an appropriate message is displayed on the MCDUs:
- FMS1/FMS2 POS DIFF,
- FMS1/FMS2 GW DIFF,
- FMS1/FMS2 SPD TGT DIFF.

Pilot action is then required.

independent mode

In independent mode, there is no interaction from one system to the other one. The FMGCs only send their status information to each other (e.g., in this case, the independent mode).

SINGLE MODE

In single mode, both MCDUs are driven by the same FM part, but they can still display different pages. Messages linked to the navigation process are displayed on both MCDUs.

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mcdu

As already presented in the FM OPERATING MODES topic, the MCDUs work differently. In normal mode, the MCDUs can be used simultaneously on different pages. Any modification or entry on one MCDU is sent to the other MCDU via the FMGC cross talk.
In independent mode, both MCDUs operate separately. Although the cross talk is present, an entry on one MCDU is not applied to the other one. In single mode, both MCDUs basically work as in normal mode, but with the valid FMGC only.

displays

FM information is displayed on NDs and on PFDs. For FM information, in normal or independent modes, FMGC1 supplies PFD1 and ND1, FMGC2 supplies PFD2 and ND2. In single mode, the remaining FMGC supplies all the displays.

radio navigation

The schematic shows the architecture of the radio navigation receivers controlled by the FMGCs in normal or independent modes. For the selection of radio navigation frequencies and courses, in normal or independent modes, each FMGC controls its own side receivers through a Radio Management Panel (RMP). Only the actual frequencies and courses from the receivers are displayed on the PFDs and the NDs. In case of an FMGC failure, the valid FMGC controls its own side receivers as usual, through an RMP, but also the other side receivers, directly without going through a RMP. If both FMGCs fail, the crew must use the RMPs to select the frequencies and courses.

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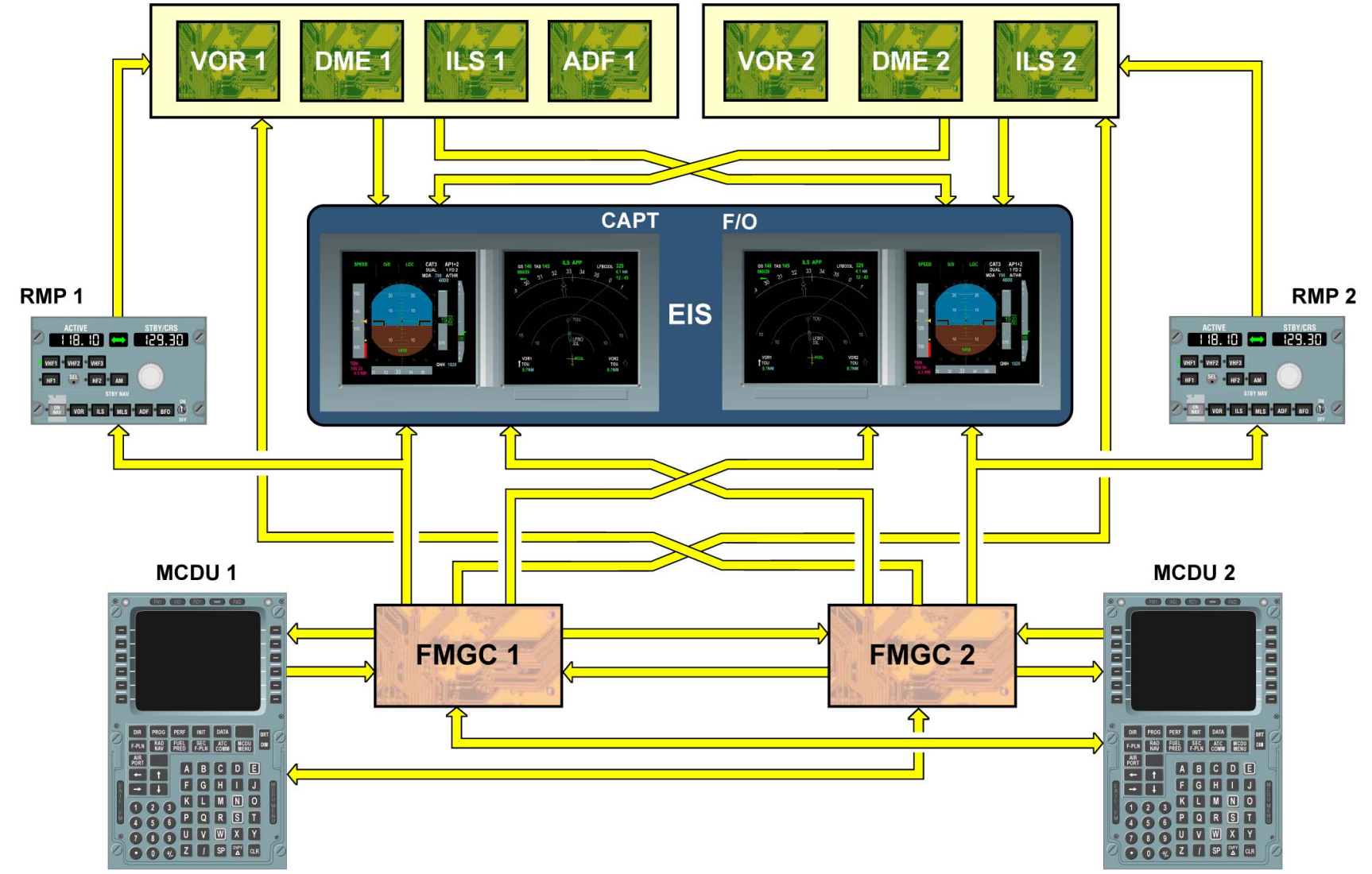

FM OPERATING MODES ... RADIO NAVIGATION

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FLIGHT PLANNING D/O (3)

FLIGHT PLAN

The flight plan is defined by various elements, which indicate the routes the aircraft must follow with the limitations along these routes.
The elements are mainly taken from the database or directly entered by the pilot. The limitations are mainly speed, altitude or time constraints originated by the ATC. The function that integrates these elements and limitations to construct a flight plan is called flight planning.
In addition to this, the Flight Management (FM) part gives the aircraft position and the follow-up of the flight plan, this is called navigation.
Everything can be prepared prior to the take-off but can also be modified quickly and easily during the flight operation. In case of an FM problem, the remaining valid Flight Management and Guidance Computer (FMGC) is used as sole source to command both Multipurpose Control and Display Units (MCDUs) and NDs after automatic switching.

NAVIGATION DATABASE

The navigation database gives all necessary information for flight plan construction and follow-up. The pilot will either select an already assembled flight plan called COmpany ROUTE, or will build his own flight plan, using the existing database contents. This database has a tailored coverage, updated every 28 days. Some room is kept to allow manual entry of 20 NAVigation AIDS, 20 waypoints, 10 runways and 3 company routes.

NOTE: Optionally, aircraft are equipped with the second generation of Flight Management System (FMS2). The room kept allows manual entry of 20 NAVAIDS, 20 waypoints, 10 runways and 5 company routes.

The database cannot be erased. However and as an option, the manually entered data can be erased when the flight phase is over (i.e. aircraft on ground for 30 seconds). Two cycle database can be loaded and the selection is made automatically by using data from the aircraft clock or manually. The database loading into either FMGC is done with the help of a Portable Data Loader (PDL) or via the Multipurpose Disk Drive Unit (MDDU) if installed. Then, the cross loading function allows database loading into the other FMGC through crosstalk busses.

NAVIGATION

The navigation process gives the system with current aircraft state information consisting of present position, altitude, winds, true airspeed and ground speed. This is achieved using inputs from the Inertial Reference Systems (IRS), air data sensors, GPS, navigation radios, Air Traffic Service Unit (ATSU) and Flight Augmentation Computer (FAC) flight envelope computation. Position can be updated manually during the flight or automatically, on the runway threshold at take-off for example.

ACARS FUNCTION

The FMS uses the Aircraft Communication Addressing and Reporting System (ACARS) function to exchange data between the ground station and the master FMGC via the ATSU. This interface makes the exchange of flight plan initialization, take-off, wind, and broadcast data and flight reports with the ground. Via the ACARS, the crew may send a request for wind data to the ground. In response to this request, or automatically, the ground sends climb, cruise, descent and alternate wind data to the aircraft.

LATERAL FLIGHT PLAN

The lateral flight plan gives the sequential track changes at each waypoint within 3 main sections.
- DEPARTURE: initial fix (origin airport), Standard Instrument Departure (SID)...
- EN ROUTE: waypoints, NAVAIDS...

- ARRIVAL: Standard Terminal Arrival Route (STAR), approach, missed approach, go around...
The lateral steering order can be followed by the pilot or the AP with the NAV mode selected.

VERTICAL FLIGHT PLAN

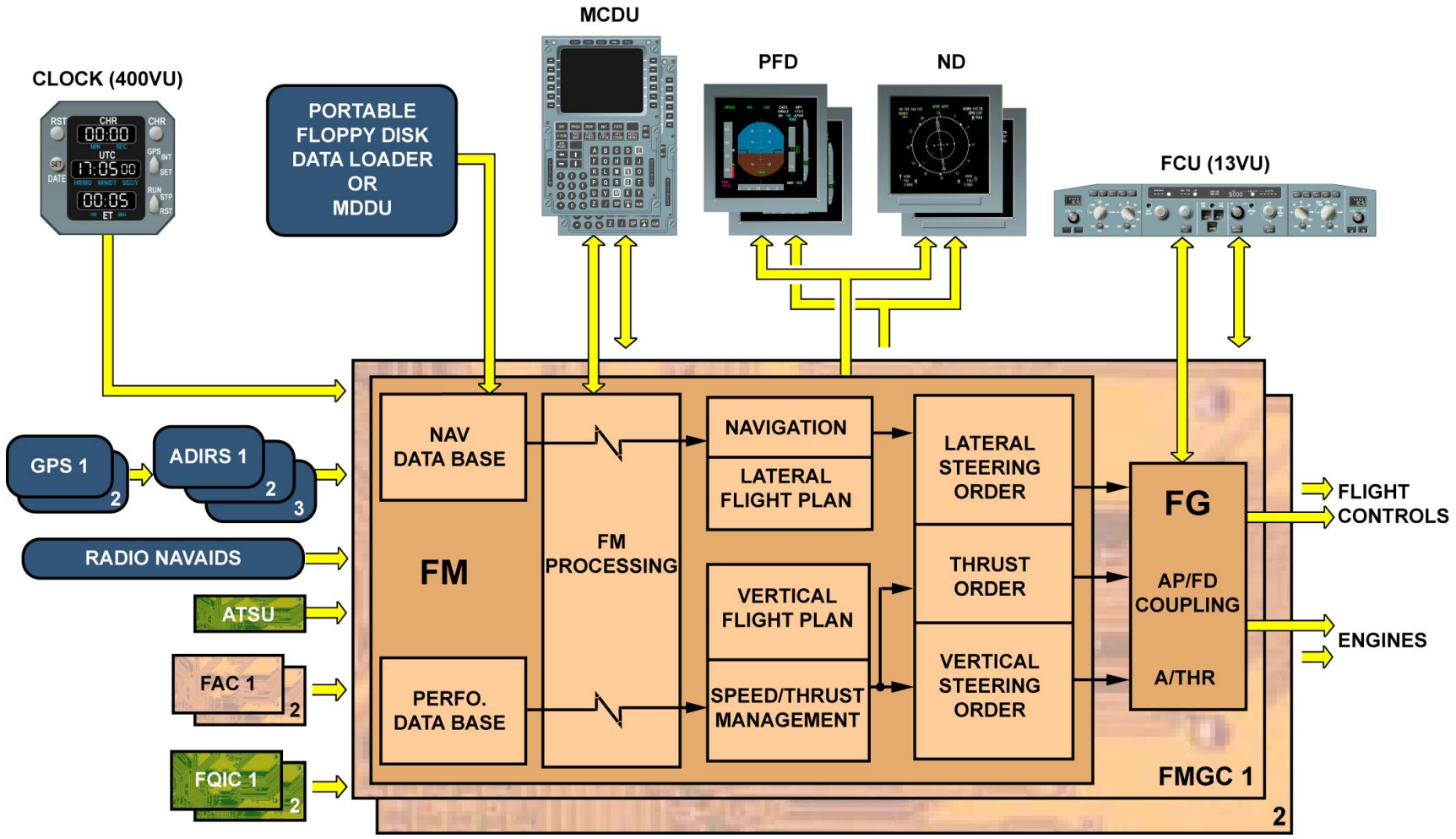
The vertical flight plan gives an accurate flight path prediction, which requires a precise knowledge of current and forecast wind, temperature and the lateral flight path to be flown. The vertical flight plan is divided into several flight phases:
- PREFLIGHT: fuel, weight and V2 insertions,
- TAKE-OFF: speed management, thrust reduction altitude, acceleration altitude,
- CLIMB: speed limit, speed management,
- CRUISE: top of climb, cruise altitude, top of descent,
- DESCENT: speed limit, speed management, deceleration,
- APPROACH/MISSED APPROACH/GO AROUND: thrust reduction altitude, acceleration altitude.
The vertical steering order can be followed by the pilot or the AP. Any level change in the vertical profile is initiated after a pull or push action on the altitude selector knob on the Flight Control Unit (FCU), except for departure when the vertical profile is armed on ground and will automatically be active after take-off phase.

PERFORMANCE

The performance database contains optimal speed schedules for the expected range of operating conditions. Several performance modes are available to the operator with the primary one being the ECONomic mode. The ECON mode can be tailored to meet specific airline requirements using a selectable Cost Index (CI). A CI is defined as the ratio of cost of time to the cost of fuel. The Fuel Quantity and Indication Computers (FQICs) give the fuel quantity. The speed and the thrust values associated with a given CI are used to determine the climb and descent profiles. Fuel and time are the main actors in this particular part of the FM function and direct the airline choice.

DISPLAY

According to the pilot selection on the EFIS control panel of the FCU, the flight plan is shown in relation to the aircraft position on the ROSE-NAV or ARC modes. The aircraft model is fixed and the chart moves. The difference between the two modes is that the half range is available when the ND is set to ROSE-NAV mode, as there is only frontal view when it is set to ARC mode. In PLAN mode, the flight plan is shown, with NORTH at the top of the screen, centered on the TO waypoint. Depending on the selected range, the aircraft may or may not be visualized on this display. The plan display can be de-centered by scrolling the flight plan on the MCDU. The PFD shows the FM guidance following engagement of the AP/Flight Director (FD) lateral and longitudinal modes.



FLIGHT PLAN ... DISPLAY

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NAVIGATION BACK-UP D/O (OPTION) (3)

GENERAL

The MCDU BACK-UP NAV (B/UP NAV) must be used as a back-up system when both Flight Management (FM) parts have failed.The MCDU BACK-UP NAV (B/UP NAV) gives to the crew limited information, which can be used to complete the current flight.
The MCDU B/UP NAV is activated through the "SELECT NAV B/UP" prompt on the MCDU MENU page.
The B/UP NAV functions work independently and may be activated separately.

FLIGHT PLANNING

Before activation of the BACK-UP NAV function, a condensed form of the flight plan is transferred from the FM part to the MCDU.
This downloading is updated in case of:
- FM primary Flight Plan (F-PLN) changes,
- FM lateral leg sequencing,
- FM long power off,
- FM source selector change,
- FM resynchronization.

Downloading includes waypoint position, waypoint identifier, leg type, discontinuity, overfly and turn direction information in a maximum of 150 legs.
At BACK-UP NAV activation, a last updating is done and then any other updating is ignored. A reduced capability is given to the MCDU B/UP NAV function compared to the FM function.

NAVIGATION

The BACK-UP NAV function is based on Inertial Reference (IR) inputs from the ownside IR or IR3, which gives the position, ground speed, track, heading, altitude and wind. The selected IR depends on pilot selection, through the IR source selector, to be consistent with the current displayed IR data on the related PFD and ND. The MCDU B/UP NAV gives, the crosstrack error and the bearing/distance/time to go to the active waypoint, depending on the aircraft latitude/longitude and on the active leg of the flight plan. It supplies the automatic leg change when the TO waypoint is reached.
It is very important to note that all this data is only for display, there is no steering order issued by the MCDU, and the NAV mode cannot be engaged.

ND DISPLAY

The MCDU transmits the BACK-UP F-PLN to the NDs. It has active F-PLN vectors and waypoints related to the fixed aircraft position in ROSE or ARC modes, or to the moving aircraft reference in PLAN mode. In all cases, the flight plan line is dashed in green (as NAV mode cannot be engaged). Options selectable on the EFIS control panel are not allowed (AiRPorT, Non-Directional Beacon, VOR.D, WayPoinT, ConSTRaint).

MCDU PAGE AVAILABILITY

All flight-planning operations are directly applied through the B/UP F-PLN page. It displays each leg of the active route, giving position information for each waypoint, as well as computed course, time and distance for the connecting legs. The revisions, available on the B/UP F-PLN page, are:
- waypoint insertion,
- waypoint deletion,
- discontinuity deletion,
- overfly deletion/insertion.

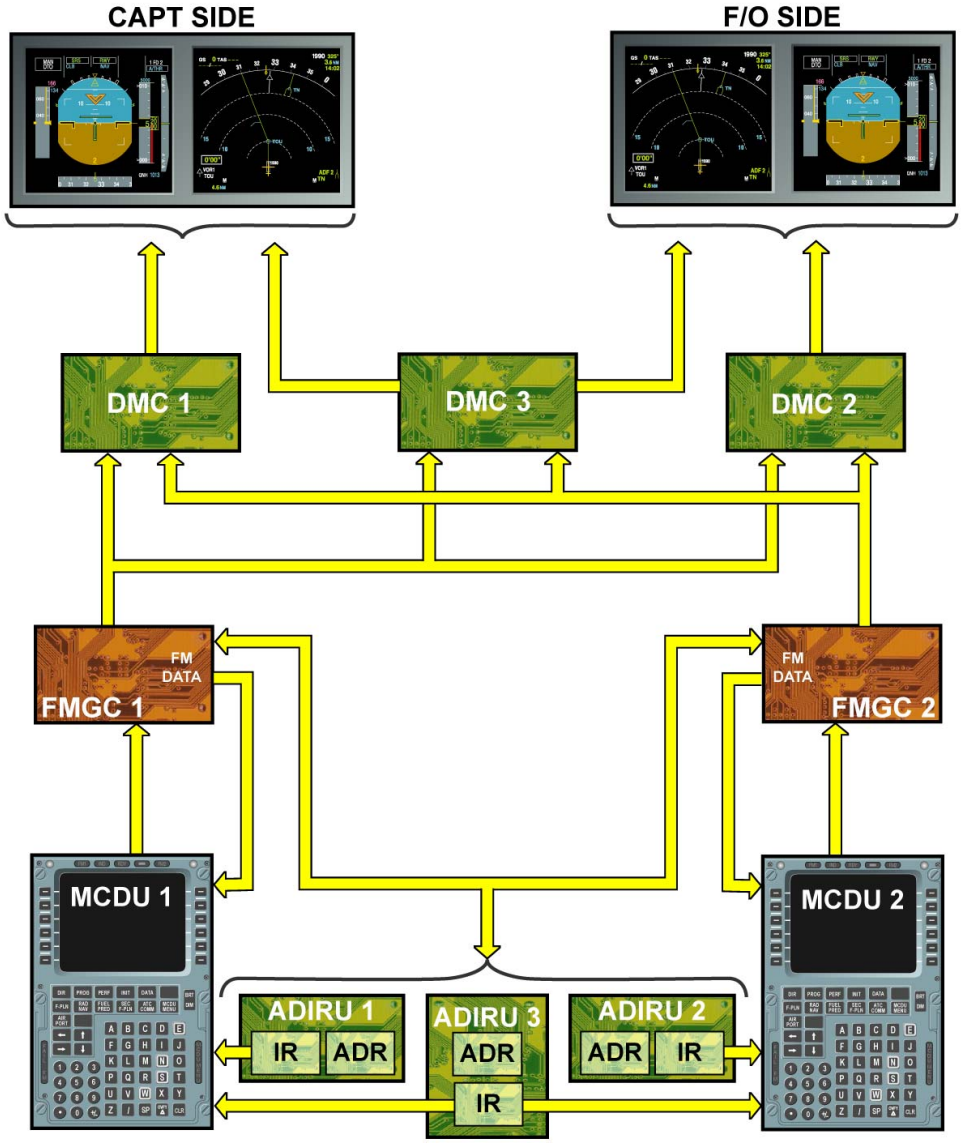
Pressing the DIR key enables the selection of a waypoint to join it directly. The B/UP F-PLN/DIR TO page is similar to the F-PLN page but line 1 is reserved for waypoint entry.
Pressing the PROGress key gives navigation information. The B/UP PROG page displays the aircraft position with identification of the selected

IR. It also gives ground speed, and active leg track with aircraft track.
The top line displays the waypoint identifier and altitude at the last sequenced waypoint, also called overhead (OVHD).
The bottom line enables access to the B/UP IRS pages. The B/UP IRS pages correspond to IR1 or 2, function of MCDU1 or 2, and IR3. IR provides, for display information about position, the true track, the true and magnetic headings, the ground speed and the wind.

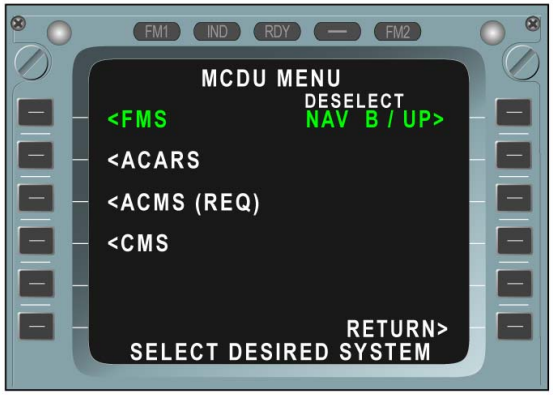
DEACTIVATION

Backup Navigation is deactivated upon one of the following events:
- The Deselect NAV B/UP prompt is pushed on the MCDU MENU page
- The following condition becomes true: onside FM is Healtly and offside FM is failed
- The FM subsystem is selected via its menu text prompt on the MENU page.

When Backup navigation is not available, no Select NAV B/UP nor Deselect NAV B/UP prompt is displayed. The field is blank. Upon Backup Nav deactivation, the Backup Nav functions are disabled and the FM is given back control of the Nav Display.



MCDU



ND

GENERAL ... DEACTIVATION

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AUTO FLIGHT SYSTEM OPERATION, CONTROL & INDICATING (3)

FMGC FAILURE

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